ARTICLE XIII.

Observations on Nebulæ with a Fourteen Feet Reflector, made by H. L. Smith and E. P. Mason, during the year 1839. *By E. P. Mason. Read April* 17, 1840.

1. ALTHOUGH a period of nearly fifty years has now elapsed since the researches of the elder Herschel exposed to us the wide distribution of nebulous matter through the universe, we are still almost as ignorant as ever of its nature and intention. The same lapse of time that, among his extensive lists of double stars, has revealed to us the revolution of sun around sun, and given us a partial insight into the internal economy of those remote sidereal systems, has been apparently insufficient to discover any changes of a definite character in the nebulæ, and thereby to inform us at all of their past history, the form of their original creation, or their future destiny. At the same time, the detection of such changes is in the highest degree desirable, since no other sources of evidence can be safely relied upon in these inquiries. That the efforts of astronomers have thus far ended, at best, in vague and contradictory conjectures, is principally attributable to the great difficulty of originally observing, and of describing to future observers, bodies so shapeless and indeterminate in their forms, with the requisite precision. For, we cannot doubt, authorized as we are to extend the laws of gravitation far into the recesses of space, that these masses of diffused matter are actually undergoing vast revolutions in form and constitution. The main object of this paper is to inquire how far that minute accuracy which has achieved such signal discoveries in the allied department of "the double stars," may be introduced into the observation of nebulæ, by

modes of examination and description more peculiarly adapted to this end than such as can be employed in general reviews of the heavens. The observations which are detailed in this paper are brought forward in illustration of this inquiry.

2. It will conduce to a clearer understanding of our object to point out, generally and rapidly, the distinctions between our own theory of observation and that commonly adopted. It consists not in an extensive review, but in confining the attention to a few individuals; upon these exercising a long and minute scrutiny, during a succession of evenings; rendering even the slightest particulars of each nebula as precise as repeated observation and comparison, with varied precautions, can make them, and confirming each more doubtful and less legible of its features by a repetition of suspicions, which are of weight in proportion as they accumulate; and, lastly, when practicable, correcting by comparison of the judgments of different persons at the same time.

Thus much for observation—for rendering the idea of the object as perfect as may be in the mind of the observer. For the most unimpaired communication of this idea or perception, the theory of the process adopted is briefly, 1st. To form an accurate chart of all stars capable of micrometrical *measurement* in and around the nebula. 2d. From these, as the greater landmarks, to fill in with all the lesser stars, down to the *minimum visible* by *estimation*, which, with care, need not fall far short of ordinary measurement. 3d. On this, as a foundation, to lay down the nebula. After this preparation, subject to no material distortion, except such digression from the original perception of the observer as the difficulties of accurate representation by a shaded ground and subsequent copying and engraving may cause. Lastly, the process includes the adoption of a method of representing nebulæ, intended to remove the formidable and acknowledged difficulties just named, and at the same time to introduce a numerical precision in the manner of expressing on paper their various features; thereby transmitting the best impressions of observation with almost unimpaired fidelity, and entailing only the necessary defects of original vision. It is not supposed that this process, as more fully to be illustrated in its application, is the best adapted to meet the end in view, for greater experience and reflection would certainly suggest particular modifications, if not general alterations; nor is it intended as a description of what has been done in the present instance, but rather of what might be done, with more time, and

under more favourable circumstances, by observers of greater skill and longer practice.

3. The observations presented in the following paper are a portion of a series undertaken in the summer of 1839. The range of objects which at that time passed under inspection was considerably more extensive than the present list; but many of these were examined in a desultory manner, and the rest of those excluded are not favourable specimens of the style of observation which it is intended to exemplify. The telescope employed was of the Herschelian construction, with an aperture of twelve inches and a focal length of fourteen feet. A short description of its construction and powers will not be uninteresting, and may serve to show what degree of confidence is warranted in results obtained by its aid. Although much inferior in size and light to some of the gigantic reflectors of the Herschels, it yet is entitled to some distinction as the largest telescope on this side of the Atlantic. The instrument was first planned and begun in the summer of 1838, by my friend and classmate, Mr. H. L. Smith. A tolerably good metal was cast, after several failures, and the speculum was finally polished near the close of the summer. Mr. Smith and Mr. Bradley shared the expenses attending the formation of the mirror and erection of the telescope, and divided the long labour of grinding the speculum, and I united with them in the less tedious task of giving the mirror its final polish and figure. An account of its performance in some of our first rough trials of its figure is furnished in a note on the 174th page of the XXXVth volume of Silliman's American Journal of Science. It has since been frequently and perseveringly repolished by Messrs. Smith and Bradley; the test objects mentioned in that note, however, have been about the limit of its separating power.

4. The mode of mounting the telescope was similar to Ramage's, but ruder. The base consisted of three beams, forming a triangle, which revolved on a circular ledge of plank, by means of rollers at the angles, and which was guided truly in its circuit by a cross-piece, through which rose a central bolt, firmly driven into the ground. From the angles of this base rose three beams, meeting at a height of sixteen or seventeen feet from the ground, and a rope passed through a pulley fixed at this height, and sustained the weight of the upper part of the telescope. The lower end, containing the speculum, rested on a small platform at one of the solid angles of the base, and revolved with the frame. The quick motion in altitude was by means of the rope just men-

tioned, which passed down to a windlass at the base, while a slow motion was gained by an apparatus very similar to that described and figured in Pearson's Astronomy as attached to Ramage's telescope—a combination of ropes within the immediate command of the observer. In azimuth the whole frame could be wheeled about by a single person, and a slower motion was obtained by simply swinging the telescope by the hand, which could be done by the observer, in following a star, with perfect steadiness. At very high altitudes, the system of ropes was not available; but the weight of the upper end of the telescope was then so little that the observer could grasp the tube in his arms, steadying them by contact with the converging beams, and carry on his work nearly as well as before. This method of directing a large telescope is much ruder in description than in practice.

A light frame-work of steps, detached from the main frame, served to support the observer in his elevated situation. Against this the tube of the telescope could be steadied at any moderate elevation, by means of a simple contrivance; this, however, was never necessary unless in high winds. The tube was, at first, of wood, but was afterwards replaced by sheet iron, on account of its superior lightness and portability; it was painted outside and inside, and protected, during bad weather, by oil-cloth, the speculum at such times being taken out.

5. It was our intention, at first, to have availed ourselves of the power and light of this instrument in a meridional review of a portion of the double stars of the younger Herschel's catalogue. But a short experience convinced us that its large surface was much better adapted to observations on the fainter nebulæ than its power of separation to the examination of close double stars. And an imperfection in the casting,* which, in spite of the most patient endeavours in renewed and frequent polishing, seemed to vitiate a portion of the

* It is exceedingly difficult to obtain a good casting of so large a speculum. The metal, in itself, is of a composition that presents obstacles of no ordinary difficulty, while, from the comparative ignorance and unskilfulness of many of our workmen in this department, those facilities are not afforded for overcoming these obstacles which scientific interest in Great Britain and the older countries of Europe has conferred. For a telescope considerably less in size I have had more than fifty specula cast before I could obtain one free from imperfections, and susceptible of a very excellent figure. In the present case, the general figure of the speculum, except in the neighbourhood of the flaw I have spoken of, seemed to be excellent.

speculum near it, although it did not prevent a very perfect definition of the discs of large stars, was yet apt to throw around them flitting rays and burrs of light, sometimes hiding very close or faint companions. By a skilful application of diaphragms, these might be so far annihilated as to afford a good separation of such stars as σ Coronæ Borealis, ζ Orionis, μ^2 Bootis, γ Virginis, λ Ophinchi, and others of less than $1''$ in distance, but the loss of light by this mode of proceeding was a serious inconvenience. On objects as ill-defined as nebulæ, however, the full light of the telescope could be employed to the utmost advantage. It was not long before a strict scrutiny revealed to us many particulars concerning the nebulæ of the elder and younger Herschels, which it was obvious that they had not noticed, and in some instances spaces of nebulous matter of great extent, connected with well known nebulæ, but altogether overlooked by former observers. These considerations decided the application of the instrumental power we had obtained to this interesting field of inquiry.

6. The nebulæ which are the subjects of the present paper are 1991, 2008, 2092 and 2093 of Sir J. F. W. Herschel's large catalogue, (Phil. Trans. 1833.) These are, in reality, but three, since 2092 and 2093, as will be shown in this paper, are but parts of one very extensive nebula, united by a long, irregular band of very faint nebulous matter. These three nebulæ are among the most interesting objects in the heavens; perhaps, with the exception of Nebula Orionis and Nebula Andromedæ, the most so. They are represented in Plates IV., VI., and VII., with the stars in and near them, visible in the fourteen feet telescope. The number of objects examined is small, in order that the utmost accuracy in the delineation of the peculiar features and minutiæ of these nebulæ, attainable by protracted scrutiny, might be aimed at. This must still be limited by the unavoidable errors of judgment and the power of the telescope. It is hoped, however, that by this means something has been done to supply, in the examination of these nebulæ, the place of measurement in that of double stars, and to put in our possession data by which future changes, if there be any, can be recognised and detected in at least a few of these wonderful sidereal systems.

7. The first intention was to intrust entirely to careful *estimation* the copying of the stars which were to form the ground-work of the nebula, since no means of measurement were then at hand. The following is a sketch of the course of procedure adopted in pursuance of this plan. The limits of the

nebula were traced as far as long and close examination could discern them, and a rough chart was made of the principal stars within it. This preparation was indispensable, because, in the consequent mapping down of all the visible stars in the nebula, it was necessary to use a light out of doors, and the object, of course, became invisible. The distance between any two conspicuous stars, favourably situated in the nebula, was then chosen as a standard of reference, and from this as a base, a kind of triangulation was carried out by the eye to all the stars in the neighbourhood, and these were successively marked on a sheet of paper at the time; their magnitudes were also affixed to each according to a fictitious scale, for which a few stars, conveniently situated, furnished standards of reference as to size. A lamp was close at hand, whose light could be cut off at pleasure; an almost direct comparison was thus instituted between the stars in the field of view and those on paper, and corrections made where any distortions in the latter were observable. As the work advanced from night to night, the reference to the lamp was necessarily less and less direct, since a longer exclusion of light was necessary to see the fainter stars. Finally, the nebula itself was drawn upon the map by the guidance of the stars already copied; and although only an occasional and unfrequent reference could be made to a lamp, the stars within it had become so familiar by their constant recurrence, that the memory could, as easily as before, retain its *estimations* of distance and direction, until mutual comparison could be made between the map and the heavens.

The assistance which is rendered to the faithful description of these remarkable objects by thus laying a groundwork of stars, may be well illustrated by the familiar expedient of artists, who divide any complicated engraving which they would copy, into a great number of squares, their intended sketch occupying a similar number. The stars, which are apparently interwoven throughout the whole extent of the nebulæ, furnish a set of thickly distributed natural points of reference, which, truly transferred to the paper, are as available as the cross-lines of the artist in limiting and fixing the appearance of the future drawing.

3. In nebulæ of great extent, however correctly estimated may be the stars immediately around the standard of reference, those in the distant parts of the nebula are liable to suffer from an accumulation of errors of nearly the same kind as that arising in an extended trigonometrical survey. But if the places

of the larger stars are well settled by fixed instruments, there will be far less room for error in *estimations* which spread, as from so many centres, over the remaining intervals. It was extremely desirable, in the present case, to ensure accuracy by such a course; although it would have been preferable, had the means existed, to have resorted to it in the first instance. The opportunity was, however, fortunately afforded at a late period of this research, by the unexpected arrival of an excellent micrometer from England, belonging to Yale College, and adaptable to the ten feet Clarke's telescope in the observatory of the institution. I was enabled, by the kindness of Professor Olmsted, to avail myself of this instrument, and, during the fall of 1839, took repeated measures in right ascension and declination of so many stars in each nebula as would serve to determine, within a very small quantity, the places of those which were utterly too faint for any measurement. An abstract of these measures is contained in this paper. By these means the places of all the stars were brought to such a degree of exactness that it was thought expedient to throw them into the form of catalogues, especially as a direct reference could thus be made to any particular star, and, through it, to any portion of each nebula, without the necessity of encumbering the map with multitudes of letters or numbers. These catalogues, which are contained in Articles 37, 38 and 39, will be referred to constantly in this paper, and from them the star corresponding to any number in the catalogues will be easily found on the maps.

9. There must be a very considerable, though partial dependence, after all, upon the eye of the observer and the delicacy of its judgments. And as, in the use of any instrument, we feel unsafe and distrustful until aware of its errors and their probable amount, so in this kind of *estimation* by the eye, a knowledge of its liability to error is necessary to command the confidence either of the observer or of others in the results obtained by this means. To ascertain the liability of these charts to error from this source, I frequently drew a set of triangles upon paper, and after estimating their angles and the comparative lengths of the sides, measured the same. From the mean of a great number of trials, I found my average error in such *estimations* to be less than two degrees upon angles, and $\frac{1}{20}$ or $\frac{1}{30}$ in comparative distances. A fairer allowance may, perhaps, result from estimated angles of position and distances of double stars. I have a record of a considerable number of such, observed on the meridian during the summer of 1838, thirty-six of which are comparable

with standard catalogues. The mean error of these estimations in position is 4°, in distance .09 of the whole. As these estimations were of absolute distance, and included stars ranging from ξ Libræ and λ Ophinchi to such as were several minutes asunder, it may be inferred that the errors of merely relative distance in the drawings will be considerably less.

A still better test is afforded by the comparison of the star-charts as first copied from the heavens by simple *estimation*, with the projections afforded by later micrometrical measurement. The latter were laid over the former, and the discordances between the two are given in numbers in Article 34. By taking from that table the mean of the errors of *estimation* on each star, we find that, where they were made in the most careful manner, their average error in right ascension is about $0.^s4$, and in declination about $6\frac{1}{2}''$. These were in a space of 20′ diameter; the spaces included between the settled, or standard stars, are generally much smaller than this, and, of course, diminish the liability to error. Although the mean errors named above show that careful *estimations* need not, in small spaces, be in error to so great an amount as 5″ or 6″, (an accuracy not very far from that of actual measurement,) yet it may be well to add, that some portions of the larger nebulæ were more hurriedly and less accurately observed, as explained in Article 34. From all these sources a tolerably correct idea of the probable error of judgment, so to speak, may be deduced.

10. I will here speak of a method that I hit upon for the exact representation of nebulæ, which has essentially contributed to the accuracy of the accompanying delineations; the one referred to in Article 2. It was first suggested by the method usually adopted for the representation of heights above the sea-level on geographical maps, by drawing curves which represent horizontal sections of hill and valley at successive elevations above the level of the sea, that is, by lines of equal height; and it is the same in its principle. It is obvious, that if lines be imagined in the field of view winding around through all those portions of a nebula which have exactly equal brightness, these lines, transferred to our chart of stars, will give a faithful representation of the nebula and its minutiæ, and of the suddenness as well as of the amount of transition from one degree of shade to another. I cannot better illustrate my idea than by a reference to Plate II., the lines of which were transferred directly from the field of view to the paper in this way, and will be immediately recognised as

identical with the nebula of Plate IV. The lines marked 5 were traced in the telescope among the stars, and imagined to surround all those portions of the nebula which are of uniform brightness, and brighter than any other part. The first perceptible gradation or diminution of light is bounded by the lines marked 4, and so on, successively, to the line $\frac{1}{2}$, which represents the utmost bounds of the visible nebula. All these lines were first traced carefully by the eye, in their windings among the stars in the field, retraced by the pencil upon a map of the stars at hand, and finally corrected by repeated and mutual comparison.

11. If we suppose in Plate V. the faintest perceptible tint to be laid over all the space included within the line $\frac{1}{2}$, and upon that, another layer of shade bounded by the line 1, such that the gradation shall be just perceptible, and so go on, increasing in depth of shade, till the last tint laid on within the lines 5 shall represent the brightest portions of the nebula, we have at once a representation of *h.** 1991, giving, in its fullest perfection, the original idea of the observer, as formed with the object under his immediate and minute inspection. The great errors which are likely to arise in drawing and shading such delicate objects are done away. In the usual mode, a slight pressure of the pencil, or even the inequalities of the paper, may give a different impression of the particular features of the object from that which the observer intended; and where the gradations of shade to be represented are so extremely delicate, it cannot go through the process of engraving without still farther suffering in accuracy. In the method here proposed these sources of error are annihilated, for these lines can be drawn and corrected out of doors, with the native object in view, and can be transferred to the engraved plate without appreciable alteration.

12. In strictness, we should further suppose that these tints shade off into each other at their boundary lines, or that the lines should be drawn at infinitesimal intervals from each other, as exact theory must require, and conformity with the gradual decrease of light in the objects themselves. But, in practice, it is only necessary to draw the lines so that the spaces between them shall represent the least equal gradations of light visible to the eye, as has been

* The reference to Sir J. F. W. Herschel's catalogues is here, and elsewhere, by means of the small letter *h*, according to his own notation. So, also, *Sh* refers to "Herschel and South's Catalogue," 1824.

done in Plate V. Farther than this, of course, it would be useless to multiply lines; and these express the rate of condensation as well, and in much the same way as a series of points distributed at very small, equal intervals serve to determine the curve in which they are situated.

This method may be designated as a *method by lines of equal brightness*, in analogy with the terms "cotidal lines,"—"lines of equal magnetic intensity," &c., to which modes of expressing facts it is nearly allied.

13. In the double nebula, (Plate V.) the southern member of which is the very remarkable and well known nebula divided into three portions by dark rifts, and having a triple star in the centre, and the northern member, one hitherto overlooked, and surrounding the bright star in its neighbourhood, the *lines* of *equal brightness* enable us to recognise at once particulars such as these: that the portion of the *trifid* marked A suddenly shades off, almost to darkness, on the side towards the triple star, as is indicated by the closeness with which the lines succeed each other, while the transition outward is very slow and gradual; that the three nuclei of the southern portion, running up to shade 5, are perceptibly brighter than that of the northern, whose brightest portion is only within the line 4; and others of a similar description. It is evident, at once, that all such particulars concerning a nebula as are expressed, in the younger Herschel's nomenclature, by the terms "gradually," "suddenly," and "very suddenly—brighter in the middle," are indicated in this method by a greater and greater proximity and crowding of the lines; while the distinction between such terms as these, "suddenly brighter" and "suddenly much brighter—in the middle," are marked by a greater number of these lines intervening in the latter case than the former. It will be easy to conceive how all other particulars concerning a nebula, except, perhaps, its resolvability, and the like, can be at once embodied in the simplest form of diagram at the time of observation.

14. The half lines serve to show strongly suspected gradations of shade; for instance, within the space enclosed by the line $1\frac{1}{2}$, the nebula is suspected to brighten up a little, dividing the rift α into two branches. Many minute particulars are perfectly and readily distinguished at a glance in Plate V., but far less easily and definitely in Plate IV. And even Plate IV., as well as the other shaded drawings, owe much of their minute accuracy, in the hands of the engraver, to drawings similar in design to Plate V. They are, in fact, copied

from such, by the artist, in a way somewhat resembling the imaginary process I have described in Article 11, of laying upon them successive tints of shade.

15. It will be observed that but one nebula is represented in the figures by this method of lines. It was deemed expedient to adopt, at present, the common mode, that the drawings might be better understood. The originals by lines, however, are preserved, and are considered more accurate sources of reference.

16. I will now proceed to the immediate observations on the nebulæ, only premising that less care was taken to keep records of them in the form of a journal than to embody them in drawings. From these drawings the plates accompanying this paper have been principally compiled. I regret that I have at hand no notes of Mr. Smith's observations distinct from my own, and can, therefore, furnish only such scattered remarks of his as I have happened to record at the time. This deficiency is of little real consequence, since it was the constant practice for each of us to verify the observations of the other. Indeed, in all cases where there could be any doubt, no particular was considered as any thing more than a mere suspicion, whose existence had not been fully and independently corroborated by the other's testimony.

Observations with the Fourteen Feet Reflector.

17. *Nebula* h. 1991.

1839. *July* 12.—Saw the triple nebula in Sagittarius. The three clefts which divide it were made out without difficulty, although the whole nebula was extremely faint. Rather low in the horizon.

Aug. 1.—Observed the *trifid* nebula of Herschel. The double star is certainly not as figured in the Phil. Trans., 1833, but rather adhering to the left of the three divisions. (A diagram was made, exhibiting this peculiarity.) The star was not seen triple.

Aug. 7. Nebula IV. 41. The nebula much brighter than I have seen it before. Mr. Smith and myself both remarked that the large star (22) immediately adjoining was surrounded with a very distinct nebula, not far inferior in brightness to the trifid. It was scarcely to be overlooked, and was seen at the first glance into the field. Its limits are nearly as great as those of the trifid nebula, with which it is nearly, or quite, in contact. On looking over Herschel's observations on this nebula, it was very evident that this is to be

classed among the *Novæ*, although immediately contiguous to one of the most remarkable and frequently observed nebulæ in the heavens.

Aug. 9.—Figured some half dozen of the stars of the trifid nebula. I see distinctly the star near its centre triple, but a ray or burr of light from the larger star nearly obscures the faint companion, so that I can scarcely tell whether the difficulty of the small star consists in its closeness or faintness. Estimated distance of AB 10″; of AC 5″, but the last may easily be in error from the cause just mentioned. The triple star is certainly not central, but involved in the skirts of the division marked A in the diagram, and also is north of the point where the three clefts meet, being in the cleft γ. The division B runs up at the junction towards, or into the opposite cleft β a little way, shading off, at the same time, so gradually that, at first sight, the rift α seems to proceed more directly from the triple star than it really does.

Aug. 10.—Finished figuring the stars in Nebula Trifid. There is scarcely a visible star in the nebula above the triple star.

Figured the nebula. There is a peculiarity about the cleft α which had been suspected on the night of the 9th. It shelves off suddenly to the north with a pretty well defined boundary, which I can trace nearly up to the star (2;) if I mistake not, it divides in two, leaving an extremely faint nebulosity, or fourth portion, isolated from the rest. Mr. S. saw the sudden turn of the cleft northwards, but could not satisfy himself as to its division into two, which must therefore remain uncertain.

Peculiarities of the lower nebula.—There is a large, but indistinct vacancy, or gap, north, or below its central star, where the nebula is decidedly less bright, while, on the left hand of this vacancy, is a small portion brighter than the rest of the nebula. "I think the vacancy runs up past the central star, though narrower there."—*S.* In my own observation, I think it does not quite reach the central star, so that it remains doubtful whether the star in the centre is not somewhat isolated from the surrounding nebula. I saw the same appearance described by Mr. Smith, but considered it the effect of the brightness of the star in effacing the impression of the nebula in its immediate neighbourhood. Our estimates of the utmost extent of the lower nebula nearly agreed, although its boundary was very indefinite.

Aug. 14.—The nebula IV. 41 again examined; the moon at first troublesome, but setting. I tried, this evening, a plan for better delineating this nebula by lines which represented equal gradations of shade. I find it more convenient and direct, and, I believe, much more accurate. I think I can thus take a copy of the nebula with as much exactness as I can see it. To settle the angles of position of the triple star, lines were drawn on the star-chart, representing their apparent directions as referred to other stars in the nebula. The nebula, as delineated by lines, was compared by Mr. Smith, and verified; some slight alterations were suggested by himself, nearly all of which a re-examination confirmed, and some others added, which are better expressed in the drawing than by description.

18. *Nebula* h. 2008.

1839. *Aug.* 1.—Observed nebula M. 17. Nearly all the parts figured by Herschel in the Phil. Trans. are distinctly and beautifully seen. The night has evidently improved.

The two knots which Herschel describes in the appendix to his paper are well seen, but the upper one not resolvable; the lower one is seen by Mr. Smith and myself oval, and extending downwards. I think there is a small branch at the angle of the nebula, in a downward direction towards a coarse collection of large stars just below. A careful diagram made of this and other particulars.

Aug. 3.—The curved part of this nebula is certainly smaller in proportion to the bright following branch than is represented in Herschel's figure. The extremely faint preceding branch neither of us are able to see, although guided by Herschel's figure.

Aug. 7.—There is a coarse collection of stars below this nebula, in which I have once or twice suspected faint nebulosity. The branch before spoken of as extending downwards from the smaller of the two knots, seems to pass to the right hand part of this cluster, and, perhaps, running through it, to rise again, returning to the bright arm of the nebula, near the star (29.) This is but a bare suspicion, for an assemblage of stars often gives a deceptive appearance of nebulosity among them.*

"There is, I think, a faint ray from the internal angle of the nebula, towards the upper star of Herschel's figure (25 of Plate VI.)"—*S.* This observation of Mr. Smith's it was too late for me to verify.

Aug. 10.—Messier 17. Figured the stars in this nebula, amounting to upwards of thirty; also the principal features of the nebula. The bright following branch is remarkably devoid of large stars; it is, however, thick set with extremely small stars, just beyond the limits of distinct visibility; the places of three of these, after long attention, I have succeeded in fixing, and, with time and patience, could obtain more, but have little of either to spare; the fatigue of the eye, moreover, is extreme.

The observation made by Mr. Smith, on the 7th, of a faint ray towards the star (25) is, in a great measure confirmed; I see certainly the upper boundary of such a ray, but think it melts into, or joins with, the bright branch of the nebula below, being like a thin veil, or gauze of light, drawn up from the bright nebula, and stretched from the star to the internal

* It is scarcely to be supposed that this very common illusion is due to the sympathy of the neighbouring parts of the retina, which is only adequate to account for the usual aberration, or irradiation, of stars. If I might hazard a conjecture, I should, perhaps, attribute it to the same optical effect by which Sir J. Herschel (Mem. Ast. Soc., Vol. II., p. 490) is inclined to explain the apparent recession of the nebula Orionis from the stars of the trapezium situate within it; contrast with their strong light blotting out the nebula in their vicinity. So the diffuse starlight, which always redeems the sky from perfect blackness, may, perhaps, among many large stars, be faintly revealed by contrast with the portions effaced in the immediate vicinity of the stars. This is, at best, a very doubtful explanation, and principally thrown out for the purpose of calling attention to the phenomenon.

angle, where lies Herschel's resolvable knot. And, if I mistake not, all the space from this star to the vertex of the bend is filled up with extremely faint light. The knot is isolated from the rest of the nebula, and the vacancy in which it is situated is closed in on the right and left hand, but, I think, not above and below, or, at least, above. . . . . The nebula at the external angle stretches much farther towards the north preceding than in Herschel's figure, but with a faint shade. Mr. Smith confirms my view of his ray.

Aug. 14.—Finished the delineation of the nebula 17 of Messier by the mode of lines. The larger knot stretches faintly upwards to a second nucleus, or rather star, just above. With close attention, I am almost satisfied it is a very small star. The curve of the bright following branch is much as in Herschel's drawing; I think the curve of the faint bend differs more materially.

Aug. 19.—Attempted some observation on Messier 17, but the moon interferes. It is too late for the star seen on the 14th, in Herschel's knot, to be verified by Mr. Smith. Farther re-examination was desirable upon this nebula, and the places of the stars it contained, but such is now impracticable.

19. *Nebula* h. 2092 and 2093.

1839. *July.*—(There were several observations of little importance during the month of July, in which these two nebulæ were noted as separate, and the peculiarities of Herschel's description recorded as being "well seen.")

Aug. 1.—The faint band suspected between V. 14 and 2093 of Herschel's catalogue is fully confirmed by this evening's observation. Mr. Smith and myself were both able to trace the nebula continuously from one to the other, and the reverse, so that these are now satisfactorily ascertained to constitute one immense nebula, stretching through several fields of 30′ diameter. From the right ascensions and declinations of these two nebulæ, as given by Herschel, the whole cannot well be less than 2° or 3° long. The double star mentioned by Herschel is seen, as also the trapezium near the bifurcation, but the latter is evidently somewhat distorted in his figure. The peculiar characteristic of the upper portion of the nebula cannot be mistaken. I can think of no comparison as good as that which Herschel gives it, that of a network, or interlacing of nebula. The stars follow the disposition of this network very perfectly, and their real connexion with the nebula is as obvious as the testimony of the eye and of common sense can make it. It is almost impossible that the phenomenon can result from a mere superposition of stars; indeed, the chances against the supposition of their independence of each other must be very nearly infinite.

Aug. 3.—Attempted a triangulation among the principal stars in the great Nebula Cygni, to assist in exactly copying the nebula. Thirteen were thus taken, their angles of position with each other, and comparative distances carefully estimated and called out by one of us, while the other recorded. The power used was the ordinary observing power of 80.

Aug. 7.—Nebula Cygni. The method of fixing the places of the stars adopted on the 3d was found much too slow and tedious. I therefore fixed a lamp just beneath my feet, on the ladder of steps, and found I could, by this means, easily copy the stars from the field on a sheet of paper. I think this method is as exact as that of the 3d; I can thus correct and re-correct as long as my eye perceives any difference between the original and the copy. It is, moreover, much more rapid; I have recorded and corrected fifty-eight stars in the course of three or four hours, and affixed their magnitudes with equal care.

The nebula is, at the trapezium of stars, divided as in Herschel's figure, but just below this the larger branch forks again, or, at least, is fainter along the middle than at the edges. Mr. Smith and myself noticed this independently of each other, and without previous notice of each other's views. The brightest part of the nebula is at the bifurcation near the trapezium; the next brightest, though considerably fainter, is situated in the interlaced portion, and lies along the two stars (133) and (162.)

Aug. 9.—Figured one hundred and thirty-four stars in the same way as on August 7th; about ninety of these are new. The time occupied was about six hours. These complete all within the network portion of the nebula. All the stars down to the *minimum visibile* are put down, which are near the brighter portions of the nebula; in some excessively faint branches and convolutions, winding away to a greater distance, only those more easily seen are recorded. The scale of magnitudes is an artificial one, from 1 to 12, the star (187) being of magnitude 1, and the "*minima visibilia*" (149) and (156) being of the 12th. Care has been taken to set down every star in the dark hollows left by the interwoven nebula, and the "wonderful phenomenon" described by Herschel becomes, in this way, very apparent; for a tolerably correct representation of many of the windings of the nebula in the heavens may be obtained by simply following, on the star-chart, the courses marked out by the stars themselves. On the complete map of the stars the future nebula already strikes the eye.

In the lower part of the nebula, for convenience sake termed "the bifurcate," (while the upper may be called "the network portion,") the same faint division was seen as last night. With 220, faint stars were seen in each division of the great branch. Mr. Smith suspected another branch, turning off to the right hand, towards the bright star (8.) I am of the same opinion. There is a chain of stars, consisting of three loops, or more, which hang, festoon-like, from the preceding side of the nebula, and which seem to be mixed with nebulosity in the same way as in the network portion. If this is so, the branch noticed by Mr. Smith forms the beginning of one of those loops. But there is great liability to error where nebulosity is suspected among a congeries, or chain of stars; and especially is this the case in the present nebula, on account of the wonderful peculiarity already mentioned.

Aug. 10.—The stars along the bifurcate portion of the nebula were recorded this evening, twenty-five of which, out of between fifty and sixty, were new. On this evening, and on former evenings, the lowest power of about 80 was employed in taking all the stars down to the ninth or tenth magnitude of my scale; and a higher power of 220 was employed to ob-

tain the fainter stars of the eleventh and twelfth magnitudes, where such were deemed desirable. The nebula itself was decidedly fainter with 220 than with 80, and on this account, as well as from its great extent, the nebula was examined and figured principally with the lowest power. (These remarks apply also to the powers commonly used on the other nebulæ.)

I think the nebula terminates near a pretty bright star (1;) I cannot certainly trace it farther. Two bright stars of my first magnitude, or rather higher than any magnitude of my scale, lie a little to the left hand of this extremity. Much of the nebula was roughly figured last night; the figuring to-night completed in the network portion—also, in the faint band down to the bifurcation. The character of this band seems to change as it approaches the network, beginning to break up into windings and hollows, as if it partially partook of the strange peculiarity of that portion in its approach thereto. The other end of the nebula seems disposed, if I may so speak, to break up into rifts and branches nearly parallel, and is certainly very different in its characteristics from the upper portion.

Aug. 19.—Nebula Cygni. Thirty or forty stars were added to the extreme lower portion, of which not one-half are new. The description of the nebula by lines begun. I am still uncertain about the three loops mentioned on the 9th. If they are as suspected, there is reason to believe the same in many places all around. Indeed, the whole back-ground of the heavens around the network, and in some places below, seems intersected with loops of suspected nebulosity; it is certainly different in appearance from other portions of the heavens. The loops and lace-work, which are certainly visible, probably fade off into such as we cannot see, or, at least, can but suspect.

I am not entirely certain of the subdivision into two of the larger bifurcate branch, first noticed August 7th. With 220, two or three minute stars are set down in each of the supposed branches, which certainly add to the effect, if they do not produce it. But, with considerable attention, the division seems to exist above and below the place where these minute stars are, the nebula between the two minor branches being not much inferior to either of them in brightness. The other division, that of Herschel, is tolerably black, and very distinct. On the whole, I think the existence of a second division is confirmed.

Aug. 20.—The description of the Nebula Cygni by lines completed. The stars in the extreme lower part of this nebula are not so accurately placed as at the bifurcation and in the network, nor do they descend to as definite and equal a limit in the scale of magnitudes. But such care is obviously of less use in this lower diffuse part.

The star (83,) at the bifurcation, was suspected to be a nucleus. With 220 it appears somewhat blotty, and different from other equal stars in the vicinity. It is in the very brightest portion of the nebula, at the principal bifurcation. With long attention, I am still uncertain whether this be a nucleus or a kind of nebulous star. To determine this point must require a telescope of greater light, or, at least, a better eye. Mr. Smith had no opportunity of examining this point.

The various particulars in the figured nebulæ were confirmed by Mr. Smith on different evenings; and such points as he did not confirm are considered as uncertain.*

Micrometrical Measures of the Stars in the Nebulæ.

20. The instrument with which these were taken was the ten feet telescope of G. Dollond, belonging to the philosophical department of Yale College. The aperture of this telescope is five inches; and its defining power is such as to resolve ξ Libræ, σ Coronæ Borealis, and other double stars of between $1''$ and $2''$ distance, and to exhibit the division in the ring of Saturn with ease. The micrometer is also of Dollond's most recent construction; a parallel wire micrometer, with screws of about one hundred threads to the inch, each revolution of the screw being subdivided into 100ths upon graduated heads. Farther subdivision, when desirable, is easily made by estimation. The wires are, I

* The fourteen feet telescope used in these observations was taken down in the latter part of August. On the graduation of the class in Yale College to which Mr. Smith and myself had belonged, the reflector became wholly the property of Mr. Smith, and was removed to Ohio City, Ohio. It has already been remounted there, and in a better frame, and with more perfect adjustments than before, as an extract from a recent letter of his will show:

"The stand," he writes, "is precisely similar to the engraving, in the Philosophical Transactions, of the one erected by Ramage at the Royal Observatory, Greenwich. It is full twenty feet high, and has a sliding gallery that will hold, with convenience, four persons. The telescope swings between two parallel beams, about six feet apart; up and down these the gallery can be raised or depressed by one person easily. The telescope is constructed to roll forward, so that the mouth may be at a convenient distance from the gallery. After observing, the tube can be let down into a tight box, and locked up; the whole is supported by four iron rollers, and can be turned by one person in any direction. The apparatus for slow motion in altitude is the same as in New Haven; I have been making some arrangements for a slow motion in azimuth." Mr. Smith farther writes that he has been prevented from making any observations of importance by the continuance of unfavourable weather. He has, however, lately fitted an excellent micrometer to his telescope, the work of an American artist, and will soon be prepared for fresh labours. From his zeal and activity, with so valuable an instrument, we cannot but expect the most interesting results. By the same letter I am furnished with a note of his observations on the 16th of July, 1839, which I insert as favourably exhibiting the power and capability of the telescope about the time it was employed on the foregoing nebulæ. . . . . "July 19, 8, P.M. Saw γ Virginis with 400 and 700, the latter a single lens, very beautifully; the same evening, 10, P.M., saw λ Ophinchi distinctly separated, and at 11, P.M., ζ Bootis triple." The latter I have never seen with this telescope, nor μ^2 Bootis, which Mr. Smith says he has "frequently seen," but adds "that he could never separate η Coronæ Borealis." These afford good tests of the defining power of the instrument.

But few of the common tests of light have been observed. Favourable specimens of its "*minimum visibile*" are, however, (149) and (156) of the large Nebula Cygni, already instanced, besides two or three of the smallest stars in each of the other nebulæ. By an entry in the rough journal of observations, it appears that *h.* 250, or the "Polarissima" of Herschel, a nebula almost exactly at the pole, was, if certainly seen, a fair example of its limit of visual power.

believe, of platina; with the present telescope, they are each 2".28 in thickness: their number and arrangement, as also the construction of other parts of the micrometer, is very similar to that of Troughton's spider-line micrometer, as described in Pearson's Practical Astronomy.

21. The illumination, however, is different, and resembles that employed by Frauenhofer to render visible his lines on glass. The light falls on the wires at right angles to the optical axis of the telescope, thus illuminating them upon one side, while the rest of the field is dark. This arrangement possesses considerable advantages in rendering visible small stars, which it would be otherwise extremely difficult to measure, if, indeed, they could be seen at all in an illuminated field. I found this property of great use, since nearly all the stars I wished to measure were below the tenth or eleventh magnitude. The chief faults of the present construction were two. The scale of teeth in the field of view, which marks the number of whole revolutions, is illuminated only edgewise by the light; it was in all positions difficult, and in many impossible to be read off. Great loss of time, and sometimes impaired accuracy, was the necessary consequence. The other defect was in the size of the wires; this made the line of illumination needlessly broad, and prevented small stars from being seen near or on it, unless too faintly lighted for accuracy. Neither of these faults are necessary to this construction, and both might be remedied without difficulty.

22. The telescope, being mounted with an altitude and azimuth motion, which, moreover, was quite unsteady and liable to tremors, was ill-adapted to micrometrical observation. The mode of managing the micrometer was necessarily peculiar, and its essential differences from the common and more regular employment of the instrument I shall briefly describe. The circle of the micrometer was turned until the stars in the field ran parallel to the two moveable wires. Their transits across the fixed wire, which then represented an hour circle at that point of the heavens, were noted blindly in a book at hand, no other way being practicable with a succession of stars at intervals of a few seconds each, or occasionally of less than a second. These furnished differences of right ascension. Those of declination were obtained by bringing the moveable wires over the two stars whose difference was required. No measure was considered good in which some star, brought on one of the wires for that purpose, was not completely bisected during the whole *run* across the

field; and at each new bearing of the telescope, preparatory to a fresh run, the circle of position was altered accordingly. But in this way many measures were necessarily rejected. The farther end of the telescope was steadied by contact with a double opening window-shutter, which gradually yielded to the azimuthal motion, yet with sufficient resistance to maintain the stars in the field at perfect rest.

In declination, on account of the defects before mentioned, and others of minor importance, more than one measure could seldom be obtained during a single run across the field, and that not cotemporaneously with the transits. In addition to this, the frequent necessity of entire disadjustment of the micrometer, in order to read off the scale within the field, caused a great waste of time; so that the measurement of the stars in the nebulæ, though of less importance than the observations with the reflector, occupied very much more time and labour. And it will not be surprising, after this very incomplete statement of the difficulties which it was necessary to encounter, and of the numerous sources of error thence arising, if the following measures should, in a few cases, offer somewhat greater discordances than those which occur in observations with a steady instrument, moving in the parallel of the star, and employed in measuring objects that can bear direct vision and full illumination.

23. *Reduction of the Measures.* The *value* of the *screw*, since the field would scarce include the sun's diameter, was determined entirely by passages of known stars over a given interval, a number of which were observed nearly every evening on which any measures were taken. It was subject to a very slight fluctuation, depending on changes of temperature and minute differences of focal adjustment; and hence it was checked by a comparison of the measures of the largest differences of declination on different evenings. One revolution of the screw at its mean state was equal to $17''.640$.

The *zero error* was always measured by daylight, and was applied as a correction to the intervals of passage on all stars which were taken to determine the value of the scale, and to all measures in declination. During the fall months it increased gradually and uniformly from $+ 1''.57$ to $+ 3''.83$.

There is evidently no allowance necessary for the thickness of the wires, on account of their partial illumination, in any of the different uses to which the micrometer was applied in the present instance.

24. A correction remains to be noticed, which is due to difference of refrac tion in any two stars whose apparent differences of R. A. and Decl. have been measured. This becomes of considerable importance from the construction of the observatory, which was such as to limit the range of the telescope to comparatively low altitudes, for the stars of the nebulæ were observable only during the last two or three hours of their diurnal circles. The altitude of the object at the time of observation was therefore noted; at first, roughly, by means of a rude quadrant, or by estimation from the bearing of the telescope; afterwards, when the importance of this correction was fully known, and especially in the Nebula Cygni, where the distances measured were considerable, by recording the sidereal time of observation, from which the hour angle, and thence the altitude of the object is easily deduced. The altitude being known, the observed measures were corrected for refraction by the following equations:

If A' and D' = the observed differences of R. A. and Decl. between any two stars in the field, reckoned with their usual signs, and in minutes of space,

and A and D = the true differences, " " " " " " ,

r = difference of refraction for 1′ at the known altitude, always positive,

v = the angle of variation of the hour circle in the field of view, reckoned from the vertical around to the right hand,

and δ = the declination of the nebula,

we have these three equations:

$$(1.) \qquad D = D' + r\, D' \cos^2. v.$$

$$(2.) \qquad A = A' + 2\, r\, D' \sin. v \cos. v \sec. \delta.$$

$$(3.) \qquad A = A' - r\, A' \sin^2. v.$$

The first two are applicable to observed differences of Decl. and R. A. between two stars in the field of view; the last to observed passages of a single star between two wires, in determining the value of the scale. These equations are not such as they would be for an instrument mounted equatorially: they express the condition, that the stars in the field shall, at all altitudes, run on a parallel to one of the wires, which was, in the present instance, the only practicable mode of conducting observation.

For the three nebulæ observed the values of $r \cos^2. v$ (eq. 1,) and $2\, r \sin. v. \cos. v \sec. \delta$ (eq. 2) were calculated for every observable degree of altitude, and

their logarithms to two places tabulated. Its application to each individual measure thus becomes very easy.

25. The first column of the following series of measures contains the date of observation. In the second are the numbers of the measured stars, as referred to the catalogue. The sign — between them indicates *differences* of right ascension or declination; thus, in Art. 26, 1 — 9 stands for Decl. of star (1) — Decl. of star (9.)

The third column contains the *observed* difference of right ascension (A',) or of declination of (D'.) The fourth shows the altitude or sidereal time of observation. In the fifth is the correction for refraction due to such altitude, for declination r D' $\cos^2$. v, and for right ascension $2\,r$ D' sin. v cos. v sec. δ, according to the formulæ above given. By the addition of this correction to the observed differences in the third column we are furnished in the sixth with the *true* differences, (A) and (D.) The seventh column contains the number of measures, of which the observed difference in the third column is the mean, and the eighth shows the probable error of each single measure, or the average difference from the mean of the set; these are respectively designated by n and e.

Nebula h. 1991.

26. DIFFERENCES OF DECLINATION.

Date.	Stars.	D'	Altitude.	Correction for Refr.	D	n	e	Remarks.
Oct. 3	1 — 9	+ 905″.4	19°...18°	+ 2″.0	+ 907″.4	4	1″.2	–Very liable to be affected by slight
" 10	"	905 .4	13	3 .4	908 .8	4	0 .4	errors in pos. of wires.
Nov. 2	"	897 .6	8½..7..6..5	9 .5	907 .1	13	2 .5	–Low, but clear.
" 4	"	899 .9	10 ... 6	7 .4	907 .3	15	1 .3	
Oct. 5	2 — 9	216 .0	17 ...16	0 .6	216 .6	6	2 .2	
" 8	"	+ 215 .6	15 ...14	+ 0 .7	+ 216 .3	8	0 .7	
" 5	8 — 9	— 8 .1	no	corr.	— 8 .1	6	0 .8	
" 8	"	— 9 .6	no	corr.	— 9 .6	8	0 .7	
" 4	19 — 9	+ 60 .4	20 ...19	+ 0 .1	+ 60 .5	9	4 .4	–Star (19) invisible near the wire.
" 8	"	65 .9	17 ...16	0 .2	66 .1	8	2 .0	–Wire made as faint as possible;
" 5	21 — 9	240 .0	19 ...18	0 .5	240 .5	6	0 .5	measures decidedly better on
" 8	"	237 .7	13 ...11	1 .0	238 .7	8	0 .5	this account.
" 1	22 — 9	447 .9	18 ...16	1 .1	449 .0	3	1 .5	
" 3	"	449 .5	21	0 .8	450 .3	2	0 .7	
" 10	"	+ 450 .8	15 ...14	+ 1 .4	+ 452 .2	8	0 .4	
" 9	24 — 9	— 70 .2	20 ...18	— 0 .2	— 70 .4	6	3 .0	–Excessively difficult to measure.
" 4	25 — 9	+ 112 .4	19 ...17	+ 0 .3	+ 112 .7	8	2 .5	Probably not very accurate.
" 8	"	+ 112 .5	20 ...17	+ 0 .3	+ 112 .8	9	1 .2	–Wire made faintly visible; this
" 9	28 — 9	— 270 .2	22 ...20	— 0 .5	— 270 .7	9	0 .6	certainly adds to accuracy.

27. Differences of Right Ascension.

Date.	Stars.	A′	Altitude.	Correction for Refr.	A	n	e	Remarks.
Oct. 1	1 — 9	— 28ˢ.98	21°...19°	+ 0ˢ.11	— 28ˢ.87	6	0ˢ.29	
" 3	"	28 .8	22	0 .08	28 .72	sing.	meas.	
" 4	"	29 .04	22 ...14	0 .20	28 .84	7	0 .47	
" 9	"	— 28 .84	17 ...13	+ 0 .25	— 28 .59	5	0 .51	
" 1	2 — 9	— 8 .25	20 ...19	+ 0 .03	— 8 .22	2	0 .45	-Not seen within 1ˢ of the wire.
" 3	"	8 .8	22	0 .02	8 .78	sing.	meas.	-A second in error?
" 4	"	7 .77	22 ...14	0 .05	7 .72	9	0 .22	
" 5	"	7 .8	20	0 .03	7 .77	sing.	meas.	-Wire made very faint.
" 9	"	7 .10	19 ...13	+ 0 .06	7 .04	7	0 .19	-Wires made just visible.
" 4	8 — 9	0 .52	no	corr.	0 .52	5	0 .03	
" 9	"	— 0 .5	"	"	— 0 .50	sing.	meas.	
" 3	19 — 9	+ 5 .7	"	"	+ 5 .70	"	"	-Star invisible near the wire.
" 4	"	6 .66	"	"	6 .66	5	0 .44	-Star tolerably well seen, though
" 1	21 — 9	7 .45	20 ...19	+ 0 .04	7 .49	2	0 .35	difficult.
" 3	"	7 .1	22	0 .03	7 .13	sing.	meas.	
" 4	"	8 .20	20 ...13	0 .08	8 .28	2	0 .30	
" 5	"	9 .1	20	0 .04	9 .14	sing.	meas.	-Probably the wrong second.
" 1	22 — 9	8 .40	21 ...19	0 .05	8 .45	3	0 .20	
" 4	"	8 .85	14 ...12	0 .15	9 .00	2	0 .15	
" 5	"	8 .9	21	0 .04	8 .94	sing.	meas.	
" 9	"	8 .71	19 ...13	+ 0 .11	8 .82	7	0 .21	
" 4	24 — 9	11 .60	no	corr.	11 .60	2	0 .10	
" 5	"	11 . 2	"	"	11 .20	sing.	meas.	-Too faint to be measured with
" 4	25 — 9	11 .80	19 ...12	+ 0 .02	11 .82	8	0 .52	much accuracy.
" 9	28 — 9	+ 18 .10	19 ...13	— 0 .06	+ 18 .04	9	0 .19	

Nebula h. 2008.

28. Differences of Declination.

Date.	Stars.	D′	Altitude.	Correction for Refr.	D	n	e	Remarks.
Oct. 5	11 — 21	+ 333″.9	17°...15°	+ 0″.8	+ 334″.7	7	1 .7	
" 8	"	334 .2	19 ...18	0 .6	334 .8	8	0 .9	
" 5	16 — 21	404 .0	18 ...17	0 .8	404 .8	6	0 .8	
" 8	"	404 .1	17 ...15	0 .9	405 .0	8	0 .9	
" 5	6 — 11	232 .8	14 ...13	0 .7	233 .5	6	0 .9	}
Nov. 6	"	225 .8	16 ...13	0 .6	226 .4	11	4 .2	} -Stars (4) and (6) so faint that
" 8	"	236 .0	13	0 .7	236 .7	6	2 .3	} some of these measures are
" 2	9 — 21	251 .5	10 ... 8	1 .5	253 .0	7	1 .5	very probably of (6) and (4,)
" 4	"	252 .5	10 ... 6	1 .9	254 .4	8	1 .5	or of a point between (6) and
Oct. 5	14 — 21	443 .2	15 ...14	1 .2	444 .4	6	1 .3	(4,) but nearer (6.)
Nov. 6	14 — 11	108 .3	18 ...16	0 .2	108 .5	8	0 .8	
" 8	20 — 11	397 .7	18 ...17	0 .8	398 .5	12	1 .2	
" 8	23 — 21	55 .9	16	0 .1	56 .0	3	1 .5	} -Low; stars invisible near the
" 8	25 — 21	+ 216 .2	15	+ 0 .6	+ 216 .8	5	1 .4	} wires, and badly measured.

Date.	Stars.	D′	Altitude.	Correction for Refr.	D	n	e	Remarks.
Oct. 26	31 — 21	— 305″.6	17°...15°	— 0″.7	— 306″.3	8	0″.4	
Nov. 28	"	— 303 .7	7° 55′	— 2 .2	— 305 .9	sing.	meas.	
Oct. 26	31 — 30	+ 6 .0	no	corr.	+ 6 .0	5	0 .6	
" 28	"	+ 5 .8	"	"	+ 5 .8	4	1 .0	
Nov. 26	30 — 21	— 309 .2	9	— 1 .7	— 310 .9	2	0 .5±	
" 27	"	— 313 .3	7° 30′	— 2 .4	— 315 .7	sing.	meas.	
" 8	33 — 21	+ 12 .2	no	corr.	+ 12 .2	3	1 .7	-Inaccurate on account of the great difference of R. A., and faintness of star.
Oct. 28	33 — 31	+ 311 .2	17 ...14	+ 0 .8	+ 312 .0	4	0 .8	
Nov. 6	37 — 30	176 .1	$7\frac{1}{4}$	1 .4	177 .5	sing.	meas.	
" 8	"	176 .1	14	0 .5	176 .6	2	1 .8	
Oct. 28	37 — 31	169 .2	22 ...19	0 .2	169 .4	14	0 .9	
Nov. 26	v Sagittarii — 30	678 .9	6° 30′	6 .4	685 .3	sing.	meas.	
" 27	v Sagittarii — 21	375 .6	7° 30′	2 .8	378 .4	"	"	
" 28	"	376 .2	7° 55′	2 .6	378 .8	"	"	
" 8	36 — 21	+ 336 .2	9 ...$6\frac{3}{4}$	+ 2 .5	+ 338 .7	3	0 .3	

29. Differences of Right Ascension.

Date.	Stars.	A′	Altitude.	Correction for Refr.	A	n	e	Remarks.
Oct. 5	6 — 11	— 4^s.08	21°...11°	+ 0^s.07	— 4^s.01	12	0^s.53	The discordance of these sets arises from the proximity of the two very faint stars (4) and (6.) (See Art. 28.)
" 9	"	3 .15	20 ...18	+ 0 .04	3 .11	5	0 .18	
" 9	9 — 11	— 0 .52	20 ...18	— 0 .01	— 0 .53	5	0 .10	
" 5	14 — 11	+ 6 .80	19°...3 meas. 11°...1 meas.	+ 0 .03	+ 6 .83	4	0 .10	
" 9	"	6 .58	20 ...18	0 .02	6 .60	4	0 .32	
" 3	16 — 11	8 .2	20	0 .01	8 .21	sing.	meas.	
" 4	"	8 .08	20 ...17	"	8 .09	4	0 .04	
" 5	"	8 .61	22...19, 11	"	8 .62	11	0 .32	
" 9	"	8 .20	20 ...19	"	8 .21	7	0 .49	
Nov. 8	"	7 .93	$6\frac{1}{2}$ ...$5\frac{1}{2}$	0 .10	8 .03	3	0 .11	
" 8	20 — 11	16 .43	7 ...$5\frac{1}{2}$	+ 0 .56	16 .99	4	0 .38	
Oct. 4	21 — 11	20 .80	20 ...17	— 0 .06	20 .74	4	0 .25	
" 5	"	20 .70	22 ...20	0 .05	20 .65	4	0 .50	
" 9	"	20 .2	20	0 .05	20 .15	2	0 .10	
" 4	30 — 11	46 .82	20 ...17	0 .13	46 .69	4	0 .62	
" 9	"	46 .73	21 ...18	0 .12	46 .61	6	0 .67	
" 4	31 — 11	51 .87	21 ...18	0 .13	51 .74	4	0 .38	
" 9	"	51 .60	20 ...17	— 0 .12	51 .48	5	0 .38	
" "	36 — 11	+ 68 .30	20 ...19	+ 0 .01	+ 68 .31	3	0 .40	
" "	6 — 16	— 12 .5	19	0 .03	— 12 .47	sing.	meas.	
" "	14 — 16	— 1 .6	19	0 .01	— 1 .59	"	"	
" "	23 — 21	+ 4 .30	15 ...14	0 .02	+ 4 .32	3	0 .20	Very faint and difficult; not seen very near the wire.
Nov. 27	25 — 23	3 .20	9	0 .11	3 .31	2	0 .10	
Oct. 9	30 — 21	27 .17	18 ...13	0 .08	27 .09	9	0 .29	
Nov. 6	"	26 .7	$7\frac{1}{4}$	0 .33	26 .37	sing.	meas.	
" 28	"	28 .20	$8\frac{1}{2}$	0 .25	27 .95	2	0 .50	
Oct. 9	31 — 21	31 .97	18 ...13	0 .08	31 .89	6	0 .33	
" "	33 — 21	36 .45	no	corr.	36 .45	6	0 .68	

Date.	Stars.	A′	Altitude.	Correction for Refr.	A	n	e	Remarks.
Oct. 9	36 — 21	$48^s.48$	18°...13°	+ $0^s.09$	$48^s.57$	8	$0^s.55$	
" "	37 — 21	62 .10	14 ...13	— 0 .05	62 .05	2	0 .40	
Nov. 6	31 — 30	5 .8	no	corr.	5 .80	sing.	meas.	
" 8	"	5 .3	"	"	5 .30	"	"	
" 26, 27, 28	"	5 .04	"	"	5 .04	5	0 .44	
" 6, 8	37 — 30	33 .90	7 ... 6	+ 0 .30	34 .20	2	0 .40	
" 26, 27	"	34 .05	8 ...6½	0 .26	34 .31	2	0 .45	
" 28	"	+ 34 .0	8	+ 0 .21	+ 34 .21	2	0 .30	
" 6	v Sagittarii — 30	+ $1^h\ 0^m\ 31^s.2$	7¼	+ 0 .74	+ $1^h\ 0^m\ 31^s.94$	sing.	meas.	-Doubtless some mistake, or the telescope in some way jarred between the observations.
" 26	"	" " 32 .6	6 ...30	0 .87	" " 33 .47	"	"	
" 27	"	" " 32 .5	7 ...30	0 .69	" " 33 .19	"	"	
" 28	"	+ " " 33 .3	7 ...55	+ 0 .63	+ " " 33 .93	"	"	

Nebula h. 2092 and 2093.

30. Differences of Declination.

Date.	Stars.	D′	Altitude, or Sid. Time.	Correction for Refr.	D	n	e	Remarks.
Nov. 27	114 — 66	+ 588″.3	2^h ...$2^h\ 16^m$	+ 0″.3	+ 588″.6	10	0 .8	
" "	133 — 66	983 .3	2 25 ... 40	0 .7	984 .0	9	2 .2	
" 28	47 — 66	1092 .1	3 48 ...4 2	6 .1	1098 .2	8	1 .7	
Dec. 5	"	1094 .9	1 57 ...2 10	0 .5	1095 .4	9	2 .3	
" 10	"	1093 .3	2 32 ... 37	0 .8	1094 .1	5	2 .3	
Nov. 8	187 — 66	1599 .2	30°...14°	1 .4	1600 .6	14	4 .6	
Dec. 13	"	1593 .1	$2^h\ 20^m$... 35^m	1 .0	1594 .1	4	2 .6	
Nov. 8	176 — 66	1565 .0	30°...14°	1 .3	1566 .3	7	7 .2	
Dec. 10	47 — 133	109 .9	$2^h\ 50^m$...$3^h\ 12^m$	0 .2	110 .1	9	3 .1	
Nov. 27	187 — 133	614 .2	2 45 ...3 5	0 .6	614 .8	15	3 .0	
" "	176 — 133	576 .4	2 55 ...3 5	0 .7	577 .1	3	3 .0	
Dec. 10	103 — 133	1681 .0	2 15 ... 24	1 .0	1682 .0	6	1 .3	
Nov. 11	103 — 187	1073 .0	30°...27°	0 .4	1073 .4	6	1 .7	
" 28	"	1072 .9	$2^h\ 12^m$... 40^m	0 .7	1073 .6	18	2 .4	
" 4	190 — 187	191 .3	33°...30°	0 .1	191 .4	8	1 .0	
" 27	"	+ 190 .4	$4^h\ 12^m$... 19^m	+ 2 .5	+ 192 .9	4	0 .4	
Dec. 13	176 — 187	— 34 .1	4 10 ... 14	— 0 .3	— 34 .4	5	0 .5	
Nov. 27	193 — 187	— 1415 .1	3 30 ... 4 1	— 6 .2	— 1422 .0	10	3 .5	
Dec. 16	121 — 187	+ 379 .7	2 40 ... 50	+ 0 .5	+ 380 .2	4	1 .0	
Nov. 6	190 — 103	— 879 .7	32°...30°	— 0 .3	— 880 .0	5	0 .5	
Dec. 16	121 — 103	— 695 .2	3^h ...$3^h\ 25^m$	— 1 .0	— 696 .2	9	1 .9	
Nov. 6	24 — 103	+ 707 .4	25°...23°	+ 0 .4	+ 707 .8	6	1 .2	
Dec. 5	130 — 103	794 .6	$2^h\ 48^m$... 57^m	0 .7	795 .3	7	0 .6	
Nov. 6	40 — 103	1823 .0	16°...13°	3 .3	1826 .3	7	1 .9	
" 11	"	1822 .5	25 ...23	1 .0	1823 .5	4	1 .0	
Dec. 10	"	1824 .5	$2^h\ 38^m$... 44^m	1 .4	1825 .9	4	1 .3	
" 13	"	1828 .1	3 2 ...3 5	2 .0	1830 .1	4	1 .2	
Nov. 6	65 — 103	410 .5	23°...20°	0 .3	410 .8	10	0 .9	
" "	62 — 103	488 .8	19 ...17	0 .6	489 .4	6	0 .6	
" 28	101 — 103	1231 .1	$2^h\ 45^m$... 55^m	1 .1	1232 .2	13	1 .8	
Dec. 10	130 — 24	+ 90 .6	3 15 ... 32	+ 0 .2	+ 90 .8	10	2 .0	

Date.	Stars.	D′	Altitude, or Sid. Time.	Correction for Refr.	D	n	e	Remarks.
Nov. 6	24 — 40	— 1121″.9	29° ... 26°	— 0″.5	— 1122″.4	8	1 .1	
" 28	"	1119 .5	3h 5m... 20m	1 .7	1121 .2	8	1 .3	
Dec. 5	"	1125 .4	2 38 ... 45	0 .9	1126 .3	4	1 .4	
" 13	65 — 40	1411 .2	3 15 ... 33	2 .6	1413 .8	5	2 .4	
" 13	62 — 40	1331 .8	3 35 ... 40	3 .7	1335 .5	sing.	meas.	-Single measure, but excellent.
" 10	1 — 40	— 415 .9	4 0 ... 12	— 3 .1	— 419 .0	14	1 .8	
Nov. 28	31 — 40	+ 273 .4	4 19 ... 21½	3 .5	+ 276 .9	3	1 .8	
Dec. 13	133 — k Cygni	+ 1339 .7	2h 7m... 44s	+ 0 .6	+ 1340 .3	sing.	meas.	
" 13	66 — k Cygni	372 .9	4 1 ... 30	2 .3	375 .2	"	"	
" 16	"	+ 869 .5	2 33	+ 0 .5	+ 370 .0	"	"	

31. Differences in Right Ascension.

Date.	Stars.	A′	Altitude, or Sid. Time.	Correction for Refr.	A	n	e	Remarks.
Nov. 4	103 — 187	— 79s.06	28°...14°	+ 0s.20	— 78s.86	6	0s.40	
Dec. 13	"	79 .1	2h 42m	0 .17	78 .93	sing.	meas.	
Nov. 4	121 — 187	65 .36	28°...14°	0 .07	65 .29	8	0 .17	
" "	129 — 187	59 .81	28 ...18	+ 0 .06	59 .75	4	0 .35	
" "	133 — 187	58 .48	24 ...18	— 0 .11	58 .59	3	0 .67	
" 8	"	57 .64	27 ...12	0 .13	57 .77	8	0 .54	
Dec. 5	"	58 .6	2h 24m	0 .07	58 .67	sing.	meas.	
" 13	"	57 .7	2 42	— 0 .10	57 .80	"	"	
Nov. 4	144 — 187	53 .65	24°...14°	+ 0 .18	53 .47	2	0 .45	
" "	162 — 187	42 .80	24 ...16	— 0 .11	42 .91	2	0 .46	
" 8	"	42 .70	27 ...12	0 .13	42 .83	8	0 .24	
Dec. 5	"	43 .7	2h 24m	0 .07	43 .77	sing.	meas.	
" 13	"	42 .5	2 42	— 0 .10	42 .60	"	"	
Nov. 4	176 — 187	25 .08	28°...14°	——	25 .08	8	0 .23	
" 8	"	25 .20	27 ...12	——	25 .20	7	0 .43	
Dec. 13	"	— 24 .90	2h 42m	——	— 24 .90	sing.	meas.	
Nov. 4	190 — 187	+ 0 .59	28°...14°	+ 0 .04	+ 0 .63	9	0 .16	
" 8	"	+ 0 .58	27 ...12	+ 0 .05	+ 0 .63	6	0 .16	
" "	66 — 187	— 101 .49	27 ...12	— 0 .39	— 101 .88	5	0 .50	
Dec. 5	"	101 .4	2h 24m	0 .20	101 .60	sing.	meas.	
" 13	"	100 .72	2 18 ...40	0 .21	100 .93	3	0 .37	
Nov. 8	84 — 187	90 .05	25°...12°	0 .38	90 .43	6	0 .34	
Dec. 5	"	90 .3	2h 24m	0 .20	90 .50	sing.	meas.	
" 13	"	89 .7	2 18	0 .19	89 .89	"	"	
Nov. 8	98 — 187	82 .25	27°...12°	0 .32	82 .57	6	0 .31	
" "	114 — 187	72 .81	25 ...12	0 .26	73 .07	6	0 .37	
Dec. 5	"	73 .1	2h 24m	0 .14	73 .24	sing.	meas.	
" "	66 — 133	43 .70	2 0 & 30	0 .13	43 .83	2	0 .30	
" "	84 — 133	33 .81	2 0 & 30	0 .13	33 .94	2	0 .06	
" "	47 — 133	67 .43	2 0 ... 30	——	67 .43	3	0 .38	
" "	104 & 110 — 133	— 19 .05	2 15 & 30	——	— 19 .05	2	——	-One rough measure of each, and the mean between them taken.
	2							
" "	162 — 133	+ 14 .90	2 15 & 30	——	+ 14 .90	2	0 .10	
" "	183 — 133	50 .73	2 0 ... 30	0 .07	50 .66	3	0 .13	
" "	193 — 133	+ 62 .90	2 0 ... 30	— 0 .10	+ 62 .80	3	0 .26	
Nov. 8	40 — 103	— 51 .41	10°...7°	+ 1 .65	— 49 .76	4	0 .52	

Date.	Stars.	A′	Altitude, or Sid. Time.	Correction for Refr.	A	n	e	Remarks.
Dec. 10	40 — 103	50ˢ.80	3ʰ 42ᵐ... 52ᵐ	1ˢ.28	49ˢ.52	2	0ˢ.27	
" 13	"	49 .45	3 33 ... 38	0 .82	48 .63	2	0 .16	
Nov. 8	62 — 103	28 .87	10°...8°	0 .40	28 .47	4	0 .29	
Dec. 10	"	29 .06	3ʰ 29ᵐ... 52ᵐ	0 .27	28 .79	3	0 .48	
" 13	"	— 28 .95	3 33 ... 38	+ 0 .23	— 28 .72	2	0 .72	
Nov. 8	65 — 103	— 23 .25	10°...8°	+ 0 .34	— 22 .91	5	0 .29	
Dec. 10	"	24 .20	3ʰ 29ᵐ... 52ᵐ	0 .24	23 .96	4	0 .50	
" 13	"	— 23 .80	3 33 ... 38	0 .20	— 23 .60	2	0 .69	
Nov. 8	130 — 103	+ 17 .6	8½°	0 .94	+ 18 .54	sing.	meas.	
Dec. 10	"	+ 18 .12	3ʰ 29ᵐ... 52ᵐ	0 .43	+ 18 .55	4	0 .07	
" "	21 — 103	— 65 .83	"	0 .24	— 65 .59	3	0 .05	
" "	24 — 103	— 61 .87	"	+ 0 .34	— 61 .53	3	0 .53	
" 13	133 — 103	+ 21 .14	2 39 ... 42	— 0 .26	+ 20 .88	2	0 .57	
" "	162 — 103	+ 36 .17	"	— 0 .26	+ 35 .91	2	0 .89	
Nov. 8	101 — 103	— 2 . ±	10°...7°	+ 1 .1	— 0 .9	—	———	—No transits noted, because their diff. of Decl. is greater than the diameter of the eye-piece, though not of the micrometer. The diff. of R. A. depends on this remark from the Journal:— "Star (101) = star (103) in R. A. nearly; has several times crossed about 2ˢ ± before it.
" "	31 — 40	9 .44	"	0 .25	9 .19	4	0 .42	
" 28	"	9 .85	4ʰ 19ᵐ... 22ᵐ	0 .62	9 .23	2	0 .33	
Dec. 10	"	9 .00	4 6 ... 12	+ 0 .40	8 .60	2	0 .23	
" "	1 — 40	68 .20	"	— 0 .60	68 .80	2	0 .43	
" "	10 — 40	— 36 .25	"	— 0 .53	— 36 .78	2	0 .38	
Dec. 13	66 — k Cygni	+ 10ᵐ 39 .7	2 7 & 4 1	+ 0 .23	+ 10ᵐ 39 .93	2	0 .70	
" 16	"	+ " 39 .0	2 33 & 3 55	+ 0 .20	+ " 39 .20	2	0 .85	

32. In the farther reduction of the foregoing observations, where several sets of measures have been obtained between the same two stars, they have been combined by assigning to each a weight proportioned to the value of $\frac{n}{e^2}$; with some restrictions where either n or e are so small as to render the *weight* very minute on the one hand, or immensely large on the other. And wherever, as is frequently the case, measures have been taken through a series of stars by different steps and intervals of progress, so as mutually to check each other, the most probable results have been deduced from their combination by the method of minimum squares, and are given below.

The first column contains the numbers of the stars in the catalogues, Articles 37, 38, and 39; the second and third, the differences of right ascension and declination between the several measured stars and one assumed as a zero.

Nebula h. 1991.

Stars.	Diff. of R. A.	Diff. of Decl.
1 — 9	— 0ᵐ 28ˢ.81	+ 15′ 7″.6
2 — "	" 7 .46	+ 3 36 .3
8 — "	— " 0 .52	— 0 9 .0
18 — "	+ " 6 .39	+ 1 5 .0
21 — "	+ " 7 .90	+ 3 59 .5

Stars.	Diff. of R. A.	Diff. of Decl.
22 — 9	+ 0ᵐ 8ˢ.77	+ 7′ 31″.8
24 — "	" 11 .47	— 1 10 .4
25 — "	" 11 .82	+ 1 52 .8
28 — "	+ " 18 .04	— 4 30 .7

Nebula h. 2008.

Stars.	Diff. of R. A.	Diff. of Decl.
6 — 21	— 0h 0m 23s.75	+ 9′ 28″.5
9 — "	" " 20 .53	4 13 .7
11 — "	" " 20 .00	5 34 .6
14 — "	" " 13 .24	7 23 .6
16 — "	" " 11 .72	6 44 .9
20 — "	— " " 3 .01	+ 12 13 .1
23 — "	+ " " 4 .32	+ 0 56 .0

Stars.	Diff. of R. A.	Diff. of Decl.
25 — 21	+ 0h 0m 7s.63	+ 3′ 36″.8
30 — "	" " 26 .94	— 5 12 .1
31 — "	" " 31 .84	— 5 6 .3
33 — "	" " 36 .45	+ 0 6 .0
36 — "	" " 48 .47	+ 5 38 .7
37 — "	" 1 1 .23	— 2 16 .9
v Sagittarii — "	+ 1 0 0 .35	+ 6 17 .5

Nebula h. 2092 and 2093.

Stars.	Diff. of R. A.	Diff. of Decl.
k Cygni — 187	— 12m 21s.12	— 32′ 35″.5
1 — "	3 16 .76	+ 41 19 .7
10 — "	2 44 .74	
21 — "	" 24 .46	
24 — "	" 20 .20	+ 29 38 .7
31 — "	" 16 .88	52 55 .6
40 — "	" 7 .96	+ 48 18 .7
47 — "	" 5 .18	— 8 20 .5
62 — "	1 47 .43	+ 26 2 .2
65 — "	" 42 .03	+ 24 43 .6
66 — "	" 41 .50	— 26 36 .4
84 — "	" 30 .70	
98 — "	" 22 .57	
101 — "	— " 19 .8±	+ 38 24 .9

Stars.	Diff. of R. A.	Diff. of Decl.
103 — 187	— 1m 18s.87	+ 17′ 52″.7
$\frac{(104)+(110)}{2}$ — "	" 16 .80	
114 — "	" 13 .11	— 16 47 .8
121 — "	" 5 .29	+ 6 17 .5
130 — "	" 0 .32	+ 31 8 .4
129 — "	0 59 .75	
133 — "	" 57 .75	— 10 11 .2
144 — "	" 53 .47	
162 — "	" 42 .87	
176 — "	" 25 .09	— 0 34 .6
183 — "	— " 7 .09	
190 — "	+ " 0 .63	+ 3 13 .4
193 — "	+ " 5 .05	— 23 42 .0

Catalogues of Stars in and near Nebulæ h. 1991, 2008, *and* 2092–3.

33. The right ascensions and declinations in the following catalogues depend on the three stars A. S. C. 2063, *v* Sagittarii, and *k* Cygni respectively. Their places for A. D. 1830.0 have been assumed as follows:

A. S. C.	Name of Star.	Mag.	R. A. 1830.0	Decl. 1830.0
2063		6	17h 51m 36s.51	— 22° 45′ 58″.5
2251	46 v Sagittarii	5.6	19 11 59 .09	— 16 15 54 .9
——	52 k Cygni		20 38 38 .70	+ 30 6 17 .0

The first two only are to be found in the Catalogue of the Astronomical Society of London. Having no other standard source of reference within my reach, I have adopted for the place of *k* Cygni that incidentally given by Sir J. Herschel, in his description of nebula *h.* 2088, Phil. Trans. 1833. No. 1 of

h. 1991, in my catalogue, corresponds to A. S. C. 2063, and is in the same field with the nebula. The places of the stars of *h.* 1991 may therefore be regarded as tolerably accurate. The intervals between the other two nebulæ, and the respective stars to which they were referred, were much larger, the one occupying 1^h, the other 12^m of sidereal time; and, of course, as great exactness was not attainable by the means employed. The necessity of selecting a calm evening, and of maintaining perfect stillness in the observatory during these long intervals, on account of its height and the unsteadiness of the telescope, yet, at the same time, of correcting the uncompensated clock which was employed, by coincident observations with the transit instrument, rendered these comparisons less frequent than they otherwise would have been. The small uncertainty which this circumstance introduces into the *absolute* right ascensions of the stars is a constant error, and is of slight importance, since the places of the standard stars, as assumed above, would alone give rise to uncertainty of the same nature.

The reduced differences in Article 32 were made such as they would have been at the epoch 1830.0. The measured stars, previously arranged in the form of a catalogue, by means of the three already mentioned, were projected on paper, and compared with the original charts described in Article 7, by pricking the stars through from one upon the other.

34. To form some idea of the amount of necessary error involved in the process of estimation described in Article 7, the differences of R. A. and Decl. between the measured and estimated places in *h.* 1991 were carefully measured by a scale and vernier. They are as follows:

Star.	Error in	
	R. A.	Decl.
1	$1^s.7$	$22''.7$
2	0 .4	14 .5
8	0 .10	0 .9
9	0 .00	0 .0
18	0 .26	0 .0
21	0 .17	1 .4
22	0 .68	3 .8
24	0 .42	19 .5
25	0 .23	0 .0
28	0 .03	0 .9

It is to be noticed, that star (24) was excessively difficult of measurement, not being seen on or very near the wire. The large errors apparently

belonging to it are probably not those of estimation, but of rough and difficult measurement. The errors of star (1) are on account of its distance from the nebula, without any intermediate stars recorded; and the remainder, except (2,) are all within very close limits.

It may be farther remarked, that the errors in *h.* 2008 were generally about four times as large as in *h.* 1991; also, in *h.* 2092–3 they were three or four times as large at similar distances, and in some instances on the remote confines, much larger. More time and pains were spent on the first of the three, partly in order to ascertain how much error was *necessarily* included in the method of estimation.

35. The places of the following stars, *h.* 1991, 24; *h.* 2008, 6, 9, 23, 25; *h.* 2092–3, 129, 144, differ in a slight degree, in the catalogues, from the results of measurement. These are cases in which the measures are rendered somewhat uncertain on account of extreme faintness, and are afterwards found to disagree with the original chart. The general closeness with which the estimations coincide with good measures authorize, in these few instances, an equal, or greater confidence in the former.

36. The artificial scale of magnitudes mentioned in the observation of Aug. 9th, Article 19, was converted into the common nomenclature by comparison with various stars, incidentally noticed by Sir J. Herschel in this respect. The magnitudes assigned, in his several catalogues of double stars, to the three individuals of the triple star in *h.* 1991, and those of six stars described by him as forming a trapezium, or oval, at the bifurcation of the Nebula Cygni, (see Article 59,) are principally relied on.

The first column in the following catalogues contains the number of the star in order of right ascension; the second, its magnitude; the third, its mean right ascension; and the fourth, its mean declination, at the epoch A. D. 1830.0.

The right ascension is given to the nearest tenth of a second of time, except that of the stars measured by the micrometer, which are distinguished from the rest by the addition of a second decimal. So the declination is in even seconds for the estimated, and descends to tenths for the measured places.

NOTE.—It appears to the committee that the coefficient 2 in Mr. Mason's formula for correcting the observed difference of right ascension should be omitted, and this correction be made only half as great as Mr. Mason's. The error from this source does not, on the average, amount to more than $0^s.1$ in time in the following catalogue.

37. *Catalogue of the Stars in the Nebula* h. 1991.

No.	Mag.	R. A. 1830.0	Decl. 1830.0
1	6.7	$17^h\ 51^m\ 36^s.51$	— 22° 45′ 58″.5
2	11.12	" 57 .83	" 57 30 .4
3	16	" 58 .7	23 0 38
4	16	" 59 .7	" 1 46
5	15	" 52 0 .6	22 59 46
6	16	" 2 .5	23 2 10
7	14.15	" 4 .6	22 52 22
8	9.10	" 4 .76	23 1 15 .9
9	8.9	" 5 .28	" 1 6 .9
10	12	" 5 .3	" 1 2
11	15	" 7 .0	22 59 55
12	15	" 7 .5	23 4 14
13	15	" 8 .6	22 59 17
14	15	" 9 .5	" 55 18
15	14.15	" 9 .7	" 50 56
16	14	$17^h\ 52^m\ 9^s.7$	— 23° 1′ 41″
17	14.15	" 10 .6	" 0 28
18	16	" 11 .3	22 55 20
19	12.13	" 11 .67	23 0 1 .9
20	14.15	" 12 .6	22 49 16
21	11.12	" 13 .19	" 57 7 .2
22	9	" 14 .07	" 53 34 .7
23	15	" 14 .8	" 55 28
24	12.13	" 16 .5	23 2 27
25	12	" 17 .11	22 59 14 .0
26	14.15	" 21 .9	" 51 48
27	14.15	" 21 .9	" 50 18
28	12	" 23 .31	23 5 37 .8
29	14.15	" 28 .7	22 52 10

38. *Catalogue of the Stars in and near the Nebula* h. 2008.

No.	Mag.	R. A. 1830.0	Decl. 1830.0
1	14.15	$18^h\ 10^m\ 28^s.9$	— 16° 13′ 47″
2	14.15	" 28 .9	" 11 36
3	14.15	" 29 .3	" 13 11
4	13	" 32 .9	" 12 24
5	14	" 33 .3	" 13 51
6	12.13	" 34 .74	" 11 45
7	15	" 35 .3	" 12 43
8	15	" 36 .5	" 11 50
9	12	" 38 .51	" 17 15
10	15	" 38 .5	" 13 23
11	11	" 38 .56	" 15 44. 4
12	14.15	" 42 .2	" 13 5
13	14	" 43 .3	" 16 15
14	12.13	" 45 .32	" 13 58 .9
15	16	" 46 .0	" 13 30
16	11	" 46 .84	" 14 36 .0
17	14.15	" 47 .3	" 12 24
18	16	" 50 .8	" 13 33
19	12.13	" 54 .0	" 9 37
20	11	$18^h\ 10^m\ 55^s.05$	— 16° 9′ 9″.6
21	10.11	" 58 .56	" 21 20 .3
22	16	" 11 1 .0	" 15 21
23	12.13	" 2 .88	" 20 38
24	14	" 6 .1	" 10 57
25	12	" 6 .19	" 18 17
26	16	" 7 .7	" 14 58
27	14	" 8 .3	" 12 15
28	16	" 11 .1	" 14 31
29	12	" 20 .3	" 14 4
30	9.10	" 25 .50	" 26 31 .6
31	9.10	" 30 .40	" 26 24 .2
32	13	" 33 .3	" 19 53
33	11	" 35 .00	" 21 11 .6
34	14	" 37 .7	" 17 36
35	12	" 37 .9	" 21 25
36	11.12	" 47 .03	" 15 45 .8
37	8	" 59 .79	" 23 34 .9

39. *Catalogue of the Stars in and near Nebula* h. 2092 *and* 2093.

No.	Mag.	R. A. 1830.0.	Decl. 1830.0
1	10	$20^h\ 47^m\ 43^s.14$	+ 31° 20′ 16″.4
2	12.13	" 47 .2	" 17 52
3	12.13	48 0 .3	" 14 14
4	12.13	" 1 .9	" 14 36
5	13	" 4 .8	" 13 17
6	12.13	$20^h\ 48^m\ 5^s.6$	+ 31° 15′ 0″
7	12.13	" 6 .5	" 15 25
8	10.11	" 10 .8	" 7 16
9	10.11	" 12 .3	30 10 30
10	11	" 15 .14	31 21 18

No.	Mag.	R. A. 1830.0	Decl. 1830.0
11	13	20h 48m 18s.8	+ 31° 8′ 18″
12	12.13	" 21 .3	" 10 49
13	12.13	" 23 .4	" 10 9
14	14	" 23 .9	30 26 17
15	13	" 24 .2	31 13 26
16	12.13	" 26 .8	" 18 14
17	12.13	" 28 .4	" 11 34
18	12.13	" 28 .5	" 20 42
19	13	" 29 .1	" 8 49
20	10.11	" 33 .7	30 7 17
21	10.11	" 35 .36	31 4 10
22	13	" 35 .6	30 15 8
23	10	" 37 .5	" 7 49
24	10.11	" 39 .43	31 8 34 .8
25	13	" 40 .3	" 11 56
26	12.13	" 40 .7	30 7 32
27	12.13	" 40 .7	31 14 14
28	13	" 41 .3	30 16 6
29	12	" 41 .5	" 20 9
30	12	" 41 .7	31 15 35
31	8	" 43 .04	" 31 51 .7
32	11	" 45 .3	" 9 31
33	16	" 48 .6	" 9 10
34	16	" 49 .1	" 10 9
35	11	" 49 .1	" 4 49
36	14	" 49 .2	30 25 11
37	15	" 49 .3	" 24 35
38	12.13	" 49 .9	31 10 55
39	12	" 50 .5	30 28 4
40	8	" 51 .94	31 27 14 .7
41	16	" 52 .6	" 8 53
42	12.13	" 52 .7	30 16 52
43	15.16	" 53 .0	31 10 7
44	11	" 53 .9	" 15 45
45	12	" 54 .2	30 25 31
46	12.13	" 54 .3	" 31 26
47	11	" 54 .50	" 30 35 .5
48	14	" 56 .6	" 22 33
49	12	" 57 .2	31 1 9
50	12.13	" 57 .8	" 1 32
51	14.15	" 58 .1	" 9 28
52	15	" 58 .4	" 9 39
53	13	" 59 .8	30 10 4
54	12.13	49 0 .3	" 30 32
55	12.13	" 0 .8	" 11 7
56	12	" 2 .7	31 11 47
57	12	" 3 .2	" 12 14
58	14.15	" 7 .2	30 30 2
59	12.13	" 7 .3	" 9 58
60	13	" 9 .0	" 10 32
61	12.13	" 10 .3	" 23 55
62	10.11	" 12 .38	31 4 57 .9
63	12.13	" 13 .4	30 9 27
64	13	" 14 .5	" 33 7
65	10.11	" 17 .77	31 3 39 .3

No.	Mag.	R. A. 1830.0	Decl. 1830.0
66	10	20h 49m 18s.09	+ 30° 12′ 19″.3
67	13	" 18 .6	" 59 48
68	14.15	" 19 .4	" 28 44
69	12.13	" 20 .2	31 6 4
70	12.13	" 21 .5	30 9 41
71	14	" 22 .0	" 8 33
72	12	" 24 .5	" 22 16
73	14.15	" 24 .9	" 32 1
74	16	" 24 .9	31 4 23
75	12.13	" 25 .1	30 8 36
76	15	" 25 .2	31 5 46
77	12	" 25 .9	30 23 21
78	16	" 26 .1	31 6 16
79	12	" 26 .6	30 25 21
80	13	" 26 .7	" 27 25
81	12.13	" 26 .7	" 59 54
82	14.15	" 27 .4	31 4 9
83	15	" 28 .4	" 7 34
84	10.11	" 28 .90	30 12 26
85	12	" 29 .0	" 15 22
86	14.15	" 29 .2	" 33 44
87	12.13	" 29 .5	" 57 35
88	13	" 29 .6	" 59 9
89	15	" 30 .4	" 27 44
90	12.13	" 31 .4	" 56 34
91	14	" 31 .9	31 8 40
92	12.13	" 32 .5	30 10 4
93	14	" 33 .4	31 4 51
94	14	" 33 .6	" 1 5
95	13.14	" 36 .7	30 58 13
96	15	" 36 .8	" 27 7
97	12.13	" 36 .9	" 8 33
98	10.11	" 37 .03	" 15 21
99	14.15	" 37 .6	" 18 36
100	12.13	" 38 .8	" 14 25
101	10.11	" 40 .1	31 17 20 .4
102	10	" 40 .9	30 3 17
103	10	" 40 .89	" 56 48 .1
104	11	" 41 .5	" 29 16
105	15	" 41 .6	" 28 25
106	13	" 43 .2	" 32 35
107	15	" 43 .3	" 26 29
108	12.13	" 43 .4	" 22 7
109	12	" 43 .5	" 21 13
110	11	" 44 .6	" 28 43
111	15	" 45 .0	" 20 29
112	12.13	" 45 .3	" 15 7
113	14	" 46 .4	" 23 16
114	11	" 46 .52	" 22 7 .6
115	12.13	" 48 .2	" 19 22
116	12	" 48 .3	" 20 16
117	12	" 49 .2	" 52 20
118	12.13	" 51 .8	" 20 30
119	13	" 53 .0	" 34 26
120	14	" 53 .5	" 23 14

No.	Mag.	R. A. 1830.0	Decl. 1830.0
121	10.11	$20^h\ 49^m\ 54^s.41$	$+\ 30°\ 45'\ 12''.8$
122	12.13	" 54 .9	" 49 24
123	15	" 55 .5	" 25 6
124	12.13	" 57 .7	" 52 8
125	15	" 58 .1	" 23 52
126	14.15	" 58 .4	" 23 7
127	14.15	" 58 .9	" 30 33
128	14	" 59 .2	" 42 53
129	10.11	" 59 .46	" 47 13
130	10.11	" 59 .48	31 10 3 .6
131	14.15	" 50 1 .6	30 27 26
132	14.15	" 1 .7	" 31 26
133	10.11	" 1 .89	" 28 44 .0
134	12.13	" 2 .5	" 53 40
135	14	" 2 .5	" 31 45
136	12.13	" 2 .6	31 4 19
137	14.15	" 2 .6	30 23 10
138	13	" 2 .7	31 0 59
139	12.13	" 5 .9	" 1 6
140	14.15	" 6 .1	30 42 52
141	10.11	" 6 .1	" 11 46
142	14	" 6 .6	" 18 11
143	14	" 6 .9	" 40 36
144	11	" 7 .2	" 52 39
145	15	" 7 .8	" 32 30
146	12	" 8 .2	" 49 26
147	12.13	" 8 .3	" 23 3
148	14.15	" 8 .4	" 42 52
149	16	" 9 .0	" 22 40
150	15	" 9 .4	" 29 49
151	14.15	" 9 .4	" 29 8
152	13	" 10 .3	" 22 52
153	13	" 11 .3	" 23 5
154	14.15	" 11 .7	" 29 23
155	12	" 11 .9	" 54 12
156	16	" 12 .2	" 23 8
157	14	" 13 .6	" 18 13
158	14	" 14 .0	" 25 50

No.	Mag.	R. A. 1830.0	Decl. 1830.0
159	14	$20^h\ 50^m\ 15^s.3$	$+\ 30°\ 40'\ 23''.$
160	12.13	" 16 .1	" 51 35
161	13	" 16 .6	" 40 41
162	10.11	" 16 .77	" 28 56
163	12	" 18 .1	" 43 13
164	14	" 18 .5	" 26 50
165	14	" 18 .5	" 41 56
166	12.13	" 19 .4	" 34 14
167	13	" 20 .2	" 26 6
168	14	" 21 .4	" 33 13
169	13	" 24 .0	" 29 38
170	13	" 26 .6	" 33 12
171	14.15	" 29 .2	" 17 26
172	14	" 32 .1	" 28 18
173	12.13	" 32 .2	" 16 24
174	12.13	" 33 .3	" 18 3
175	14	" 34 .6	" 34 24
176	10	" 34 .58	" 38 20 .3
177	13	" 35 .0	" 33 51
178	14	" 35 .7	" 27 17
179	12	" 38 .7	" 13 34
180	12.13	" 42 .7	" 33 4
181	14	" 44 .8	" 39 53
182	12.13	" 49 .4	" 35 0
183	10.11	" 52 .49	" 19 13
184	12	" 53 .6	" 20 1
185	12.13	" 56 .9	" 32 36
186	13	" 57 .0	" 28 11
187	8.9	" 59 .66	" 38 54 .6
188	12.13	" 59 .8	" 20 54
189	14	51 0 .1	" 21 30
190	9.10	" 0 .30	" 42 8 .0
191	11	" 2 .7	" 28 19
192	11	" 3 .2	" 29 30
193	10.11	" 4 .62	" 15 12 .5
194	11	" 10 .8	" 26 41
195	12	" 21 .3	" 18 46
196	11	" 22 .7	" 18 22

40. Of these three catalogues the first is probably the most correct. The stars in nebula *h.* 2008 are less determinate. This is chiefly due to the somewhat hurried completion of the map of that nebula in the month of August, the moon becoming troublesome sooner than was altogether convenient. And for the purposes of correction, only two or three stars exist in, or very near this nebula, of a magnitude as great as the eleventh; so that it was necessary to place reliance on the extremely difficult measures of the twelfth and thirteenth magnitudes.

But one set of measures in Decl. were taken of star (193) in the large nebula,

and this was found to differ considerably from the original map. The number of even revolutions of the micrometer screw may possibly have been read off wrong; and, if this is the case, some eight or ten stars in its neighbourhood will be affected by its error. But these are out of the direct course of the nebula. In general, the *relative* places are well determined by these right ascensions and declinations.

Description of the Plates.

41. By far the greatest obstacles to the successful comparison of modern observations on nebulæ with those which own, at least, a brief antiquity, exist in the want of precision with which the labours of former observers have been conducted; and hence all attempts to trace the slow progress of their changes end in uncertain conjectures and conflicting probabilities. I shall not, therefore, incur the charge of unnecessary minuteness in endeavouring to render, by every means, our knowledge of the present form and state of at least these few nebulæ, as far as possible, standard, and, although laden with the necessary imperfections of original observations, yet free from adventitious and unnecessary vagueness in the communication of them. In order to supply, to any future observer, those slight particulars which a chart cannot easily urge upon the notice of any but the original compiler, and, farther, to indicate the degree of certainty with which different features of the nebulæ were recognised, it is thought proper to bring under this head the enumeration of various facts not expressed in the journal of observations. These are divided into "*things certain*," "*nearly certain*," *strongly suspected*," and "*slightly suspected.*"

42. The plates are such as to distort, as little as possible, the relative position of the stars, since the development of the spherical surface is by projection on a plane tangent to the centre of each nebula.

The nebulæ are in the position in which they appear in a Herschellian reflector, when on the meridian; "*south*" being uppermost in the present cases, and the *preceding*, the right hand portions. The letters *s*, *p*, *n*, *f*, on the plates, serve as ready references where these terms are used in description.

In plate V., where one of the nebulæ is represented by lines of equal brightness, (Article 12,) the half lines serve to indicate suspected gradations of shade, while the even numbers mark those that are more certain. Thus, the lines 1

are the utmost limits of nebulous light perfectly and *certainly* visible, while the line $\frac{1}{2}$ is about as far as it is suspected to extend. The line $1\frac{1}{2}$ also encloses a space suspected to be a little brighter than the surrounding parts.

Nebula h. 1991.

43. *Things certain.*—1. A large nebula surrounding the star 22, not hitherto noticed. (See Art. 17, Aug. 7 and 10.)

2. A slight diminution of its light within the pentagon formed by the stars 15, 20, 27, 26 and 22. (Art. 17, Aug. 10.)

3. It is more extensive on the northern than southern side, but its gradation or concentration is evidently from all directions toward the bright star 22.

4. (In the trifid nebula.) The particulars concerning the attachment of the triple star to the skirts of the part, A, and of its eccentricity in other respects, as mentioned in Art. 17, Aug. 1 and 9.

5. The rift α suddenly shelves outwards and to the north, forming a tolerably definite boundary, as is indicated by the comparative closeness with which the lines succeed each other. (See Art. 17, Aug. 10.)

6. This boundary is convex inwards, or towards the stars 3 and 5.

7. The gradation from light to darkness on the inner boundary of the portion A., is somewhat more sudden than on that of the other two.

8. And in all three, it is more sudden, on the inner, than on the outer boundaries.

44. *Nearly certain.*—1. The portion B extends down to the stars 2 and 21.

2. It also runs up a little into the cleft β, fading off very imperceptibly, (Art. 17, Aug. 9.)

3. The boundary of A. running down from the triple star, turns faintly off at an obtuse angle at the star 19, while a portion of somewhat less intensity, encompasses the star 25. This fact is expressed in Plate V., by the bending of lines 2 and 3 at that point, and their proximity; the line 1 diverging from them to the star 25.

4. The upper extremity of A, between the stars 12 and 28, runs up to a pretty sharp angle.

5. (In the northern nebula.) A slight increase of intensity on the right hand of the vacancy; it is enclosed by the line 4. (Art. 17, Aug. 10.)

45. *Strongly suspected.*—1. A slight brightening up of the nebula where enclosed by the line $1\frac{1}{2}$, as if beginning to break up into a still farther subdivision. This, if real, subdivides the dark branch α, into two, in its outward course. (Art. 17, Aug. 10.)

2. The filling up of the clefts with faint nebulosity.

3. The same between the northern and southern nebula, faintly uniting the two.

46. *Slightly suspected.*—1. The angular irregularity on the south and fainter side of the part C, rendering it not unlike a shell with a sub-angular margin.

Nebula h. 2008.

47. *Things certain.*—1. The "resolvable knot" mentioned by Herschel (Art. 58, Phil. Trans. 1833,) near the star 18, is isolated, or nearly so, from the rest of the nebula. (Not seen resolvable by us. See Art. 18, Aug. 10.)

2. The smaller knot is apparently not affected with this peculiarity.

3. Of the faint bend or loop at the right hand, the following half is brighter than the preceding.

4. The bright branch fades gradually away to the left, terminating near the star 36; it is convex upwards.

5. The external angle of the nebula stretches down from the star 17, towards the north, preceding much farther than in Herschel's drawing. (Art. 18, Aug. 10.)

6. The bend in the drawing of Sir J. Herschel is too large, especially in a vertical direction, when compared with the bright following branch. (Art. 18, Aug. 3 and 14.)

48. *Nearly certain.*—1. The bright branch is more definitely bounded on its upper or southern side, than upon the lower.

2. From the larger knot at the internal angle of the nebula, a faint ray proceeds as far as star 25. (Art. 18, Aug. 7 and 10.)

3. The upper margin of this ray is tolerably definite, and thence it spreads downwards till it mingles with the brightness below. (Art. 18, Aug. 10.)

4. The "resolvable knot" of Herschel has either a second nucleus, or involves a faint star (18) in its upper margin. (Art. 18, Aug. 14.)

5. The partially vacant space in which it is situated is closed in by the ne-

bula on the right and left, and perhaps beneath, but is more open upward. (Art. 18, Aug. 10.)

6. The star 11 is too far down the preceding limb of the bend in Sir J. Herschel's figure; it should be nearer the vertex.

7. A slight protrusion from the upper curve of the bend involves the star 9.

49. *Strongly suspected.*—1. Very faint nebulosity stretching across from star 25 to star 9, filling all the internal angle of the nebula. (Art. 18, Aug. 10.)

2. Faint nebulosity extending from the stars 6 and 4 to or beyond star 2.

3. A considerable, but faint diffusion of the nebula at the external angle towards the north preceding.

4. The fainter knot stretches still more faintly a little way downward. (Art. 18, Aug. 1.)

5. Just above star 16 is a portion a little brighter than the rest of the bend.

50. *Slightly suspected.*—1. An extension of the appearance mentioned in No. 4 of Art. 49, downwards, past stars 19 and 20. (Art. 18, Aug. 1 and 7.)

2. A bare suspicion of nebulosity among a coarse cluster of stars between 11^m and $11^m\ 30^s$, and in about—16° 8′ or 10′ Decl. (Art. 18, Aug. 7.)

Nebula h. 2092 and 2093.

51. *Things certain.*—1. The brightest accumulation of nebulous matter is within the triangle formed by stars 69, 83 and 93.

2. Not much inferior to this in intensity is the portion included between the bright stars 133 and 162. (Art. 19, Aug. 7.)

3. The brightest loop of the network portion is a figure not altogether unlike a Greek υ, turned thus $\subset$, and containing No. 2, just described. The first or upper bend of this figure contains two curious triplets of stars, very similar in position and magnitude; the south following angle has in it a quintuple or sextuple star, of which two individuals, 149 and 156, are about the *minima visibilia* of the 14 feet reflector. (Art. 19, Aug. 9.)

4. These two, No. 1 and 3, are the two great nuclea of the nebula.

5. From the north following angle of the υ, at the star 162, a branch proceeds southward, of brightness little inferior to that of the υ; for the sake of shortness, I call this ψ, though possessing no resemblance to that letter.

6. All the other loops and branches in this region except the υ and ψ are extremely faint.

7. The obtuse angled parallelogram, preceding the *v*, certainly exists.

8. All, or nearly all, the visible stars in its neighbourhood are as certainly arranged along its course in apparent intimate connexion with it. (Art. 19. Aug. 9.)

9. It is, without doubt, connected to the *v*, in the way represented in the figure.

10. The loop which parts from the *v* at the quintuple star, and passing outwards by the stars 157 and 142, rejoins it near the double triplet of stars.

11. That this loop sends out a very faint branch towards stars 171 and 174, is more than "nearly certain," though not absolutely so.

12. The same may be said of a slight nebulosity in the region of the stars 183 and 184.

13. That the stars in this neighbourhood are, to a certain extent, disposed in the same order as the nebulous matter, forming rude chains, or loops, coincident with those of the nebula, is certain. This feature is most strongly developed in the *v*, and in the parallelogram No. 7 of Art 51, and though less striking, is certainly recognisable in the circuits Nos. 3, 8, 9 and 10 of Art. 52, and in the branch No. 1, of Art. 53. (Art. 19, Aug. 1 and 9.)

14. (Proceeding downwards now towards the triangle of bright stars on the parallel of 30° 40′;) the faint band connecting *h.* 2092 and *h* 2093, branches from the ψ near the star 166, and taking the conspicuous stars 176, 121, 129, and 103, in its course, brightens at last into the very considerable intensity mentioned in No. 1. This connexion undoubtedly exists. (Art. 19, Aug. 1.)

15. The faint branch starting from this band near its connexion with the ψ towards stars 177 and 180, is about as certain as that of No. 11.

16. The faint branch in the opposite direction, starting from the ψ at stars 166 and 168 towards star 119,—is certain.

17. (In the bifurcate portion.) Of the two main branches into which it forks, the upper or *s p*, is far the widest and most conspicuous. They are much too nearly equal in the drawing of Sir J. Herschel.

18. The *n f* branch extends but little beyond the double star 56, 57.

19. The *s p* branch reaches much farther, fading away in diffused nebulosity nearly or quite as far down as star 1. (Art. 19. Aug. 10.)

52. *Nearly certain.*—1. The long faint trace of light, No. 13 of Art. 51, appears, at first sight, a band of nearly uniform breadth and light, and tolerably

straight. But with long attention, the irregularities represented in the figure are pretty certainly made out. The narrow winding part differs in intensity from the rest of the band too minutely to be at all represented in an engraving, unless much exaggerated, as in Plate VI. The chief irregularities are attended with little doubt, and are as follow:

2. (Beginning at the upper end;) it bends outward so as to involve the the bright star 176, fading off very diffusely in the concavity on the opposite side.

3. It forms an ill-defined, and scarcely complete loop around the stars 163, 165, 161, 159, 143, 128; it being faintest and most imperfect on its *p* or *n p* side. It is at this point, that, in tracing the nebula from north to south, it first begins to assume the remarkable peculiarity of interweaving with stars in loops or network. (Art. 19, Aug. 10.)

4. Turning from the bright stars 121 and 129, it bends, perhaps more than in the drawing, towards the stars 146 and 160 on the following side, involving the former and the pretty bright star 144 in its course.

5. Bending back to the preceding side, it very nearly reaches, and perhaps involves, the bright star 103.

6. On the opposite side, it faintly diffuses itself to a considerable distance, fading away nearly or quite as far as the stars 138 and 139; the space between these and 155, 134 being, however, quite vacant.

7. After crossing the parallel of 30° 0′, it soon grows brighter, and passes into the bifurcate portion.

8. (In the network portion.) A very faint loop, whose extremities are the branches Nos. 11 and 15 of Art. 51, and which takes in its course No. 12 of the same, is either "nearly certain" or "strongly suspected." Its course, beginning from the south, is along the stars 174, 183, 184, 188, 189, 194, 191, 192, 180, and 177.

9. The extension of branch No. 16 of Art. 51 as far as star 119.

10. This branch also sends off a subdivision towards or along stars 145, 135, 132 and 127.

11. The part of the *v* about the double triple star brightens up a little, making a kind of feeble third nucleus with Nos. 1 and 2 of Art. 51.

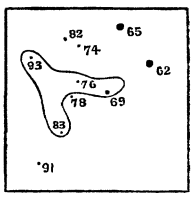
12. (In the bifurcate portion.) The broad *s p* division forks again into two, one branch of which passes, as near as can be judged, over star 32, the other be-

tween stars 32 and 24. The space between them is very little less nebulous than the branches, rendering their separate courses indefinite and somewhat uncertain. The stars of the 15th and 16th magnitudes, namely: 51, 52, 43 and 34, are in the lower, and 33, 41 are in, or just beneath, the upper of these two subdivisions. These stars prevent this from being classed in Art. 51. (See Art. 19, Aug. 7, 9, 10, 19.)

13. A diffuse and faint nebulosity fills up all the space in the principal rift.

14. The *n p* division pretty certainly involves the double star 56, 57, in its northern margin; not as Hershel describes and figures it, passing clear of it to the south.

15. At the point of bifurcation, the nebula runs up to a dense nucleus of somewhat definite outline, the figure of which, as referred to the stars in that quarter, is, by a careful comparison of the drawings of two evenings, as in the margin. The fork originates very near, or at the star 78.



53. *Strongly suspected.*—1. The faint branch of nebula, starting from the upper end of the *v*, along the bright stars 98, 84, and 66, and spreading through the cluster 97, 92, 75, 71, 70, 63, 60, 59, 55, 53. It is very faintly described in the engraving. Stars clustering thickly are so apt to deceive in this respect, that what would otherwise be considered as certain, is, in this instance, only "strong suspicion."

2. From the south preceding angle of the parallelogram No. 7 of Art. 51, a faint branch is believed to extend to star 14, or beyond. It is very slightly marked in the engraving.

3. The branch No. 9 of Art. 52 probably completes the loop by joining the *v* at the two bright stars 104 and 110.

4. The branch No. 10, of Art. 52, also probably extends to the *v*. It is pretty definitely bounded on its preceding, but fades diffusely on the following side, filling nearly all the vacancy between it and the ψ with vague nebulosity.

5. The ψ seems to be barely disjoined from the *v* at and near the star 162, as if it were in the act of breaking away by the force of contrary attractions. This may very possibly be owing to the effect of the bright star 162 in apparently effacing the nebula in its immediate vicinity.

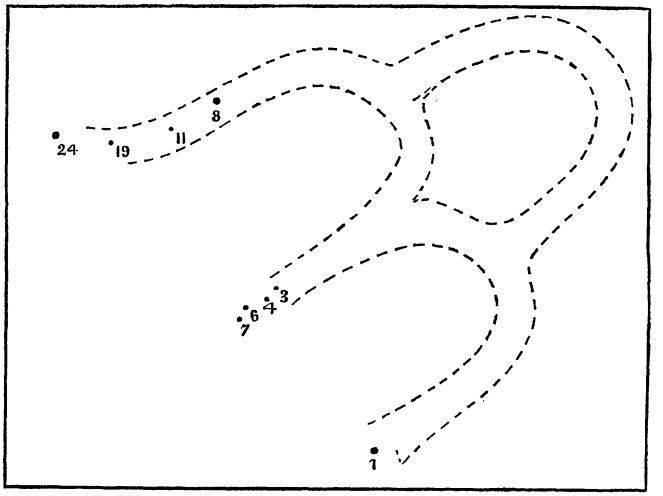
6. From the northern extremity of the parallelogram, No. 7 of Art. 51, near stars 54 and 47, the loop faintly marked in the engraving probably curves round and joins the loop No. 3 of Art. 53, near the stars 106, 119.

7. The loop No. 10, of Art. 51 is very indefinite on its inner margin, and perhaps very faint nebulosity fills all the interior.

8. The star 83, in the bright portion No. 15 of Art. 52, is believed to be peculiar,—blotty or nebulous. (Art. 19, Aug. 20.)

9. A branch curves off from the principal division of the bifurcate portion along the stars 24, 19, 11, 8. This would be certain but for the reason mentioned in No. 1 of this article. (Art. 19, Aug. 9.)

54. *Slightly suspected.*—1. Nebulosity in the three loops of stars mentioned in the observations of Aug. 9 and 19, Art. 19. They run in the direction represented in the margin, and a portion of them are also faintly traced in the plate of the nebula. The stars 24, 19, 11, 8,——7, 6, 4, 3, —— and 1, constitute but the several starting points, or origins, of these connected series of stars.



2. From the *s p* angle of No. 7, Art. 51, near the stars 45, 61, —— faint nebulosity extending among the stars 48, 29, 42, 28, 22, perhaps joining the cluster in No. 1. of Art. 53.

3. Some straggling interlacing of nebulous matter and stars to some distance *s f* the *v*, towards stars 179, 193, 196.

4. A possible extension of irregular rings and branches of nebulosity, spreading down from the parallelogram No. 7 of Art. 51, and its proximate branches, to the loops of No. 1, as above. (Art. 19, Aug. 19.)

5. The surface of the sky around is broken with almost visible wisps, and imaginings of nebulous matter,—for I can somewhat express by these terms that troubled appearance of the heavens, which continually suggests the idea of nebulosity, yet disappointing all closer scrutiny. (Art. 19, Aug. 19.) I have little doubt that, with a telescope of not much greater power, the range of this nebula might be considerably extended, and hope, at some future time, to have the means of doing so, or to see the conjecture investigated by others at an earlier date.

Former Observations of these Nebulæ.

55. All the light which we can obtain on the past history of these nebulæ becomes of great moment in the inquiry, 'Whether their present form and character are now sufficiently well determined to be a standard for the future?' I have therefore collected into one group in order of time such scattered notices of each as I have been able to find; the collection of which, as independent observations, differing greatly in point of time, is of considerable interest in detecting some important errors, and in ascertaining the probable stability of the nebulæ. And, furthermore, the distinguishing characteristics of that mode of observing and describing the nebulæ, which it is a chief object of this paper to explain, will be more distinctly illustrated by a comparison of former with the present observations.

56. At the time of pursuing these inquiries with the 14 feet Reflector, the great catalogue of Sir J. Herschel, (Phil. Trans. 1833,) was the only one with which Mr. Smith and myself were acquainted; the common abridgment of the Philosophical Transactions previous to 1800, contains of the elder Herschel's catalogues, only a very full preface and explanation of the observations, with the unfortunate omission, however, of the observations themselves,—an arrangement not very well adapted to the convenience of future observers. Recently, however, having access to the greater part of the original papers, I am enabled to extract from them:

H. V., 10, 11, 12; H. IV., 41; *h.* 1991.*

40 of the 145; Sh. 379.†

57. *Sir William Herschel; First Catalogue of* 1000. *Phil. Trans.* 1786, *Part II.*

Cl.	No.	Date.	Star.	Diff. of R. A.		Diff. of Decl.		No. of Obs.	Remarks.
V.	10 11 12	July 12, 1784.	5 (i) Sagittarii	Foll.	$2^m\ 42^s$	North	0° 49′	1	Three nebulæ, faintly joined, form a triangle. In the middle (a) is a double star. Very faint, and of great extent.

* Synonyms of the nebula.

† Synonyms of the triple star in its centre.

Sir William Herschel; Second Catalogue of 1000. *Phil. Trans.* 1789, *Part II.*

Cl.	No.	Date.	Star.	Diff. of R. A.		Diff. of Decl.		No. of Obs.	Remarks.
IV.	41	May 26, 1786.	14 Sagittarii	Prec.	$11^m\ 58^s$	South	1° 15′	1	A double star with extensive nebulosity of different intensity. About the double star is a black opening resembling the nebula in Orion in miniature.

Sir William Herschel; "On the places of 145 *new Double Stars." Mem. Ast. Soc., Vol. I., Part I.*, 1822.

(40.) 566 sweep. May 26, 1786. A double star within neb. IV. 41. 14 *Sagittarii* prec. $11^m\ 58^s$, south 1° 15′; R. A., $17^h\ 49^m\ 30^s$; P. D., 113° 1′

Sir William Herschel; Astronomical Observations relating to the Construction of the Heavens, arranged for the purpose of a critical examination, &c." Phil. Trans. 1811, *Part II. Under the* 11*th division "of treble, quadruple, or sextuple nebulæ," the example adduced is that of this nebula, as follows:*

Among the treble nebulæ there is one, namely, V. 10, of which the nebulosity is not yet separated. "Three nebulæ seem to join faintly together,[c] forming a kind of triangle; the middle of which is less nebulous, or perhaps free from nebulosity[c]; in the middle[a] of the triangle is a double star of the second or third class; more faint nebulosities are following[d]."

"*Mr. Herschel's and Mr. South's Observations of the apparent Distances and Positions of* 380 *double and triple Stars."—Phil. Trans.* 1824, *Part II. In the "Supplementary Catalogue of Twenty," less perfectly measured than the rest, on account of uncommon difficulty, &c., is a measure of the central star:*

No. CCCLXXIX. R. A. $17^h\ 52^m$; Decl. 22° 58′ S. 40 of the 145.
Double; 9th and 10th [e] magnitudes.
July 11, 1823. Five feet Equatorial.
Position = 61° 45′ ± s p; Distance = 10″. 952 ± single measures. "South."
May be easily measured in the 7 feet, but in its present place it cannot be directed to it.

Sir J. F. W. Herschel. "An Account of the Actual State of the Great Nebula in Orion, compared with those of former Astronomers." Mem. Ast. Soc., Vol. II., Part II., 1826. *In a note on p.* 490 *he says:*

"However, in the nebula R. A. $17^h\ 52^m$, N. P. D. 113° 1′ in Sagittarius, which belongs to the same class of objects as that in Orion, the idea of an absorption by the double star in its middle is very forcibly suggested. This nebula is broken into three parts, and the three lines of division meet in a vacancy[c], in the midst[a] of which is situated the double star. This curious object has, perhaps, a proper motion.

[a] Art. 17., Aug. 1 and 9; Art. 43. 4. [c] Art. 45. 2. [d] Art. 61. [e] Art. 36.

Sir J. F. W. Herschel. Second Catalogue "of 295 new Double and Triple Stars, discovered in the course of a series of Observations with a twenty feet Reflecting Telescope. Mem. Ast. Soc., Vol. III., Part I., 1827.

No.	R. A. 1830.0	N. P. D. 1830.0	Angle.	Quadrant.	Dist.	Mags.	Remarks.
——	$17^h\ 52^m\ 1^s.5$	113° 2′ 2″	60°	s p	10″	9, 10[e]	A most curious and interesting object; a double star placed exactly in the central (a) vacuity of a large irregular nebula, which appears to have broken up into three portions by three rifts, or cracks, extending from its centre to its circumference, and whose directions meet (b) at the double star. Twice observed in R. A., and three times in P. D. Δ R. A. = $7^s.1$. Diff. of greatest and least P. D. = 84″. H. and S. 379. (61° 45* s p, 10″.952.)

Sir J. F. W. Herschel, in the prefatory remarks to the same paper, says:

The curious double star R. A. $17^h\ 52^m\ 1^s.5$, so remarkably situated "where three ways meet," in the midst of a very large and conspicuous nebula, affords a striking instance how easily the latter class of objects may be overlooked in the usual mode of conducting astronomical observations within doors, with lights burning and the field illuminated. Mr. South measured this star in the five feet equatorial, but the nebula which formed so very striking an appendage to it escaped his notice entirely, &c.

Sir J. F. W. Herschel. "Fifth Catalogue of Double Stars observed at Slough, in the years 1830 *and* 1831, *with the twenty feet Reflector, &c." Mem. Ast. Soc., Vol. VI.*, 1833.

No. *h.*	R. A. 1830.0	N. P. D. 1830.0	Pos.	Dist.	Mag.	Remarks.	Sweep.	Reference.
——	$17^h\ 51^m\ 56^s.9$	113° 1′ 29″	218°.0	10″	8, 9.10[e]	Beautifully triple. In nebula IV. 41.	275	S *h.* 379.
			22 .5	3	8, 10	Daylight observation; nebula not observed.		
	——	——	216 .4	14	——	Position, mean of 216°.0, 217°.1, 216°.2. Triple. Before the close star could be measured, it clouded.	276	
			20 ±	5±				

Position from diagram. If the rough measure of S *h.* 379 could be relied upon, the star B must have varied in position greatly.(f) C overlooked by my father, and by S *h.*

Sir J. F. W. Herschel. "Observations of Nebulæ and Clusters of Stars, made at Slough, with a twenty feet Reflector, between the years 1825 *and* 1833." *Phil. Trans.* 1833, *Part II.*

No.	Synonym.	A. R. 1830.0	N. P. D. 1830.0.	Description and Remarks.	Sweep.
1991	IV. 41.	$17^h\ 51^m\ 56^s.9$	113° 1′ 29″	The double star S *h.* 379 in the centre[a] of the trifid nebula IV. 41. (See my 5th catalogue of double stars. Mem. Roy. Ast. Soc. and fig. 80.)	275†
		62 .4	0 41	A careful drawing taken, but the nebula is not clear from twilight and clouds. (N. B. This drawing is unfortunately lost, and that engraved in fig. 80 is constructed from much less elaborate sketches, aided by memory.)	32
		64 .3	0 6	Very large; trifid, three nebulæ with a vacuity in the midst[c], in which is centrally situated[a] the double star S *h.* 379, nebula = 7′ in extent. A most remarkable object.	30
		. . . .	0 43	Seen in its place, but clouds prevented observation.	31

[b] Art. 17, Aug. 9; Art. 43. 4. [f] Art. 62.

* There is an erratum here in the Mem. Ast. Soc. For "81° 45′," read "61° 45′."

† Should it not be 276? There is an erratum either here or in the catalogue referred to, since against "sweep 275" in that catalogue is the remark "Daylight observation; nebula not observed."

M. 17; *h.* 2008.

58. *Sir William Herschel.* "*On the Construction of the Heavens.*" *Phil. Trans.* 1785, *Part I.* **M. 17** *is included in the enumeration of seven* "*very compound nebulæ, or milky ways,*" *which* "*cannot be otherwise than of a wonderful magnitude, and may well outvie our milky way in grandeur,*" *as follows:*

The seventh is a wonderful, extensive nebulosity of the milky[g] kind. There are several stars visible in it, but they can have no connexion with that nebulosity, and are, doubtless, belonging to our own system scattered before it. It is the 17th of the Connaissance des Tems.

Sir J. F. W. Herschel. "*Observations of Nebulæ and Clusters of Stars, made at Slough, with a twenty feet Reflector, &c.*" *Phil. Trans.* 1833, *Part II.*

No.	Synonym.	A. R. 1830.0	N. P. D. 1830.0	Description and Remarks.	Sweep.
2008.	M. 17	$18^h\ 10^m\ 44^s.2$	106° 17′ 55″	The principal star[h] in the preceding arc of the horse-shoe-like portion of the nebula M. 17. See fig. 35.	163
		46 .8	14 5	The small, insulated, resolvable knot[h] in the following* strait branch of the nebula.	274
		51 .8	14 19	The same knot. See description of this nebula in the Appendix. See also the figure.	358
		. . . .	15 48::	A most curious object, not unlike the nebula in Orion, (as it used to be figured, like a Greek capital omega, Ω.) There is in it a resolvable portion, or knot, distinctly separated from, and insulated in the rest, as if it had absorbed the nebula near it[i]. (A figure carefully drawn.) (The P. D. inaccurate[h], being much past meridian.)	33
		. . . .	15 27::	A large extended nebula. Its form is that of a Greek Ω with the left (or following) base-line turned upwards. The curved (or horse-shoe) part is very faint, and has many stars in it. The preceding base-line hardly visible[k]. The following, which is the principal branch, occupies nearly half the field, ($7\frac{1}{2}'$.) Its light is not equable, but blotty.[g] Strong twilight.	48

Sir J. F. W. Herschel. "*Notes on the List of Figured Nebulæ,*" *in the* "*Appendix*" *to the above paper.*

Fig. 35, MESS. 17.—The figure of this nebula is nearly that of a Greek capital omega, Ω, somewhat distorted, and very unequally bright. It is remarkable that this is the form usually attributed to the great nebula in Orion, though in that nebula I confess I can discern no resemblance whatever to the Greek letter. MESSIER perceived only the bright following* branch of the nebula now in question, without any of the attached convolutions which were first noticed by my father.[l] The chief peculiarities which I have

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[g] Art. 18, Aug. 10.

[h] The north polar distances of these two points are, as given here, on the average, about 2′ larger than mine.

[i] Art. 47. 1; Art. 48. 4, 5.

[k] Art. 49. 2.

[l] I have not been able to find Sir William Herschel's notice of these; and perhaps they are not published, since Sir J. Herschel, in another part of this paper, refers to his father's "observations of MESSIER's nebulæ, (which," he adds, "are not included in his catalogues,) &c."

* Two errata occur here in the Phil. Trans. In both instances, for "preceding" read "following."

observed in it are, 1st, the resolvable knot in the following portion of the bright branch, which is, in a considerable degree, insulated from the surrounding nebula; strongly suggesting the idea of an absorption of the nebulous matter[l]; and, 2dly, the much feebler and smaller knot at the north preceding end of the same branch, where the nebula makes a sudden bend at an acute angle[m]. With a view to a more exact representation of this curious nebula, I have, at different times, taken micrometrical measures of the relative places of the stars in and near it[n], by which, when laid down as in a chart, its limits may be traced and identified, as I hope soon to have better opportunity to do than its low situation in this latitude will permit.

V. 19; *h.* 2092 and 2093.

59. *Sir William Herschel.* "*On the Construction of the Heavens.*" *Phil. Trans.* 1785, *Part I. The 2d and 3d of the seven "very compound nebulæ, or milky ways," which "cannot be otherwise than of a wonderful magnitude, and may well outvie our milky way in grandeur," both belong to this extensive nebula:*

The *second*[o] is an extremely faint milky ray, above $\frac{3}{4}$ of a degree[p] long, and 8 or 10′ broad[p]; extended from north preceding to south following. It makes an angle of about 30 or 40 degrees with the meridian, and contains three or four places that are brighter than the rest. The stars of the Galaxy are scattered over it in the same manner as over the rest of the heavens. It follows ε Cygni 11.5 minutes of time, and is 2° 19′ more south.

The *third*[q] is a branching nebulosity of about a degree and a half in right ascension, and about 48′ extent in polar distance. The following part of it is divided into several streams, which, after separating, meet each other again towards the south. It precedes ζ Cygni 16^m in time, and is 1° 16′ more north. I suppose this to be joined to the preceding one; but, having observed them in different sweeps, there was no opportunity of tracing their connexion.

Sir William Herschel; First Catalogue of 1000. *Phil. Trans.* 1786, *Part II.*

Cl.	No.	Date.	Star.	Diff. of R. A.		Diff. of Decl.		No. of Obs.	Remarks.
V.	14	Sept. 5, 1784.	52 (k) Cygni	Foll.	$11^m\ 24^s$	North	0° 44′	2	Branching nebulosity, extending in R. A. near 1½°, and in P. D. 52′. The following part divides into several streams, uniting again towards the south.(r)

Sir William Herschel. "*Astronomical Observations relating to the Construction of the Heavens, arranged for the purpose of a critical examination, &c.*" *Phil. Trans.* 1811, *Part II. Under the first of the many classes into which he had arranged them, we have:*

1. Of Extensive Diffused Nebulosity.

The first article of my series will begin with extensive diffused nebulosity, which is a phenomenon that

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[m] Art. 47. 2; Art. 49. 4; Art. 50. 1.

[n] In Sir J. Herschel's present drawing, the places of at least four or five stars seem to have been settled by measurement.

[o] Corresponding to *h.* 2092; Art. 64.

[p] I should think over-estimated.

[q & r] Corresponding to *h.* 2093; Art. 64.

hitherto has not been much noticed, and can, indeed, only be perceived by instruments that collect a great quantity of light.

* * * * * * * * * *

The description of the object I shall select is of No. 14 in the 5th class, and is as follows[s]:—"Extremely faint branching nebulosity; its whitishness is entirely of the milky kind, and it is brighter in three or four places than in the rest; the stars of the milky way are scattered over it in the same manner as over the rest of the heavens. Its extent in the parallel is nearly $1\frac{1}{2}$ degree, and in the meridional direction about 52 minutes. The following part of it is divided into several streams and windings, which, after separating, meet each other again towards the south." See figure 1.

Sir J. F. W. Herschel. "*Observations of Nebulæ and Clusters of Stars, made at Slough, with a twenty feet Reflector, &c.*" *Phil. Trans.* 1833, *Part II.*

No.	Synonym.	A. R. 1830.0	N. P. D. 1830.0	Description and Remarks.	Sweep.
2092	V. 14	$20^h\ 49^m\ 19^s.1$	58° 57′ 1″	Place of the southern and brightest star of a trapezium south of the bifurcation of this nebula. The nebula is extremely faint, very long, and straggling, extending at least four fields (= 1°)[t]. Its direction is (by diagram) about 20° n p to s f, and near the middle it forks into two chief branches. (See fig. 34.) In the trapezium (or oval) above spoken of are 6 stars, 1 = 11 m; 2 = 10 m; 3 = 12 m; 4 = 14 m; 5 = 15 m; 6 = 12 m[e]. The northern branch of the fork is the principal[u], and passes south of a double star[v] (7)[w].	199
		22.7	- - - - - -	The same star in the same nebula V. 14. The nebula is of great extent, passing obliquely through and rather under (to the north* of) a small constellation, being densest where under it; but it is extremely faint, and only to be seen with an eye well prepared, and in a very clear night. The whole neighbourhood seems affected with wisps, or cirro-stratus-like masses of nebula.[x]	198
2093	Nova.	20 50 4.4	60 26 6 [y]	(See figure 82.) A most wonderful phenomenon. A very large space, 20′ or 30′ broad in P. D., and 1^m or 2^m in R. A., full of nebula and stars mixed. The nebula is decidedly attached to the stars, and is as decidedly not stellar. It forms irregular lace-work marked out by stars, but some parts are decidedly nebulous, wherein no stars can be seen.[z] A figure (from which the drawing for the engraving was copied) represents general character, but not the minute details of this object, which would be extremely difficult to give with any degree of fidelity.	8

[s] Art. 64.

[t] Certainly over-estimated, even by the testimony of his own drawing.

[u] It is not so in his drawing. Also, see Art. 51. 17; Art. 52. 12.

[v] Art. 52. 14.

[w] I cannot conjecture to what this "(7)" refers.

[x] Art. 19, Aug. 19; Art. 54. 4.

[y] Art. 65.

[z] Art. 19, Aug. 1 and 9; Art. 51. 8, 13.

* There seems to be an erratum here in the Phil. Trans. For "to the s. of," read "to the n. of."

Sir J. F. W. Herschel. "Notes on the List of Figured Nebulæ," in the "Appendix" to the above paper.

Plate XVI. Figs. 80, 82, 83, 84, 85, represent nebulæ which offer some remarkable peculiarity of situation with regard to stars. Of these the most singular are IV. 41, (fig. 80,) and that of fig. 82. The latter, however, is very imperfectly expressed in the drawing. Indeed, it would be excessively difficult to execute a drawing of such an object with any pretensions to correctness. In this, general resemblance and character only has been aimed at, enough to express the peculiar feature of the object, which is a network or tracery of nebulæ following the lines of a similar network of stars. It is an extremely faint and difficult object, and only once observed; but I do not think it possible I could have been deceived as to the reality of the phenomenon,[z] especially since the brighter parts of the nebula are stated in the observation to have been distinctly seen.

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60. A number of interesting results are deducible from the comparison of these observations with each other, and with those embodied in this paper, some few of which I shall point out.

61. The large nebula surrounding star 22 of *h.* 1991, appears to have escaped the eyes of both the elder and younger Herschels. Unless we construe the remarks of Sir Wm. Herschel in his paper of 1811, that "more faint nebulosities are following," as a notice of this nebula. But, had Sir Wm. Herschel actually seen the nebulous companion, which, surrounding a bright star at so short a distance from the principal triple nebula, at once renders the whole system one of the most wonderful and instructive in the heavens, it is in the highest degree improbable that he would have passed over, with so light a comment, a fact more highly illustrative of his peculiar views than any of the instances he has so laboriously collected. His remark, which seems otherwise inapplicable as a description of this object, more probably refers to some smaller and very faint nebulosities, at several fields distance; one or two such were marked by us as Novæ, having no synonyms in the younger Herschel's catalogue, but for want of proper instrumental means, their places could not be settled.

62. *Measures of the triple star.* The lines drawn on the star chart to mark the directions of the components of the triple star, (see Art. 17; Obs. of Aug. 14,) were transferred to the corrected maps, and, measured by an accurate protractor, gave the following results: A B,=211°.5; A C, =15°.5, the latter not well seen. Again, from the measured right ascensions and declinations, we have

for AB, 218°.6, though, from the nature of the deduction, not much to be depended upon. An observation with the micrometer also occurs in the Journal, as follows: "Oct. 4. Two measures of AB, *s p* 52° 30′, and 55° 30′" the mean of which = 216°.0. Arranging all the measures of this star in order of time, we have

		Position.	Distance.
Herschel and South, 1823.5	61° 45′, s p	= 208° 15′	10″.9
Sir J. Herschel, 1827	60 s p	= 210 (est.)	10 (est.)
" , 1831		218 .0	10 (est.)
		216 .4	14 (est.)
Mean of the above, 1839.7		215 .4	10 .1

The conjecture of Sir J. Herschel with regard to the change of position of this star (see Art. 57, "Fifth catalogue of double stars,") seems, therefore, not to be confirmed.

63. The nebula IV. 41, and V. 10, 11, and 12, of Sir Wm. Herschel's catalogues are identical. Sir J. Herschel seems to have recognised only the former. And it appears that Sir Wm. Herschel supposed them different nebulæ, from his assigning to them two different places in his catalogues.

64. The observations on *h.* 2092 and 2093, by former observers, are in great confusion *inter se.* Of the two "compound systems or milky ways" in Sir Wm. Herschel's first quoted paper, the "second" answers to the *bifurcate*, and the "*third*" to the network portion of this nebula. If the descriptions there given did not show conclusively that this was the case, the places assigned would remove all doubt. Again; in his first catalogue of 1000, he repeats the description of the *third* milky way, under the title of V. 14, which must therefore correspond to the *network;* and the place he assigns, when reduced, becomes R. A. $20^h\ 50^m\ 0$, Decl. + 30° 50′, which exactly coincides with the brightest point of this portion. Sir J. Herschel seems to have overlooked or mistaken some of these observations, by applying the synonym V. 14 to the bifurcate portion, and calling the network "Nova," whereas both these suppositions the above comparison shows to be unwarrantable.

There is also some reason to believe, from the description in his paper of 1811, Art. 59, that the elder Herschel saw the faint band which I have shown connects these two portions, or, in other words, traced out the whole nebula; the "figure 1," however, to which he refers so immediately, exhibits no trace of resemblance to the object, as seen by us, nor is the difference such as could be caused by any difference in telescopes. Nor is it at all in favour of this belief,

that he quotes from his catalogue under the title of V. 14, which I have shown corresponds to the network only,—and assigns, as in that catalogue, an extent of 52′ in a meridional direction, a quantity entirely too small to include the whole nebula, especially when we consider that in other particulars of dimension he has rather over, than under estimated. I am therefore unable to decide this point. At the time of our own observations, and until quite recently, I did not know that there was *any* ground for attributing to the elder Herschel a full view of the whole nebula; and the remarks of the younger Herschel, show conclusively, that he was not aware of their being united, nor so understood his father's observations.

65. It will be seen, by reference to the figured nebulæ of Sir J. Herschel, that his figure 34 represents that portion of our largest nebula, included between the parallels 30° 55′ and 31° 20′ in Plate VII. Figure 82 represents the general character of the portion between 30° 10′ and 30° 40′.

66. The N. P. D. of *h.* 2093, as given by Herschel, is 60° 26′ 6″, or in declination + 29° 34′. A reference to the map or catalogue will show the brightest portion to be about + 30° 28′ 40″. The place assigned by Sir J. Herschel is therefore nearly a degree in error. I was led on this account, in early observations, to attribute to the nebula a greater extent than actually belongs to it. It does not much exceed a degree in declination, and it is between 3^m and 4^m broad in right ascension. It would be very absurd to account for the error in Herschel's place, by supposing that not this, but some nebula about a degree farther south, and unseen in our observations, is the one recorded by him. I think it probable that the confusion I have above alluded to in the synonyms of different portions of the whole nebula is chiefly owing to this mistake in P. D.